I-10/SR 85 CORRIDOR PROFILE STUDY

I-10/SR 85, CALIFORNIA STATE LINE TO I-8

ADOT Work Task No. MPD 013-16

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Draft Working Paper 2: Existing Corridor Performance

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TABLE OF CONTENTS

List of Tables

List of Figures

LIST OF ABBREVIATIONS

Abbreviation	Name
AADT	Annual Average Daily Traffic
ABISS	Arizona Bridge Information and Storage System
ADOT	Arizona Department of Transportation
AZTDM	Arizona Travel Demand Model
bqAZ	Building a Quality Arizona
BI	Bridge Index
CA	California
CR	Cracking Rating
CSS	Combined Safety Score
DCR	Design Concept Report
DHV	Design Hour Volume
EB	Eastbound
FI	Freight Index
HCRS	Highway Condition Reporting System
HERS	Highway Economic Requirements Systems
HPMS	Highway Performance Monitoring System
I	Interstate
IRI	International Roughness Index
LHMPO	Lake Havasu Metropolitan Planning Organization
LOS	Level of Service
MAG	Maricopa Association of Governments
MAP-21	Moving Ahead for Progress in the 21st Century
MI	Mobility Index
MP	Milepost
MPD	Multimodal Planning Division
P2P Link	Planning to Programming Link
PI	Pavement Index
PDI	Pavement Distress Index
PSR	Pavement Serviceability Rating
SI	Safety Index
SOV	Single Occupancy Vehicle
SR	State Route
SHSP	Strategic Highway Safety Plan
TPI	Planning Time Index
TTI	Travel Time Index
TPTI	Truck Planning Time Index
TTTI	Truck Travel Time Index
US	United States Route
V/C	Volume-to-Capacity
WACOG	Western Arizona Council of Governments
YMPO	Yuma Metropolitan Planning Organization
WB	Westbound

1. INTRODUCTION

The Arizona Department of Transportation (ADOT) is the lead agency for this corridor profile study of Interstate 10 (I-10) East between the California state line and Arizona State Route 85 (SR 85), and SR 85 between I-10 and Interstate 8 (I-8). This study will look at key performance measures relative to the I-10/SR 85 corridor, and use those as a means to prioritize future improvements in areas that show critical needs.

The intent of the corridor profile program, and of the Planning to Programming process, is to conduct performance-based planning to identify areas of need and make the most efficient use of available funding to provide an efficient transportation network. ADOT is conducting eleven corridor profile studies. The eleven corridors are being evaluated within three separate groupings.

The first three studies (Round 1) began in spring 2014, and encompass:

- I-17: SR 101L to I-40
- I-19: Mexico International Border to I-10
- I-40: California State Line to I-17

The second round (Round 2) of studies, initiated in spring 2015, includes:

- I-8: California State Line to I-10
- I-40: I-17 to the New Mexico State Line
- SR 95: I-8 to I-40

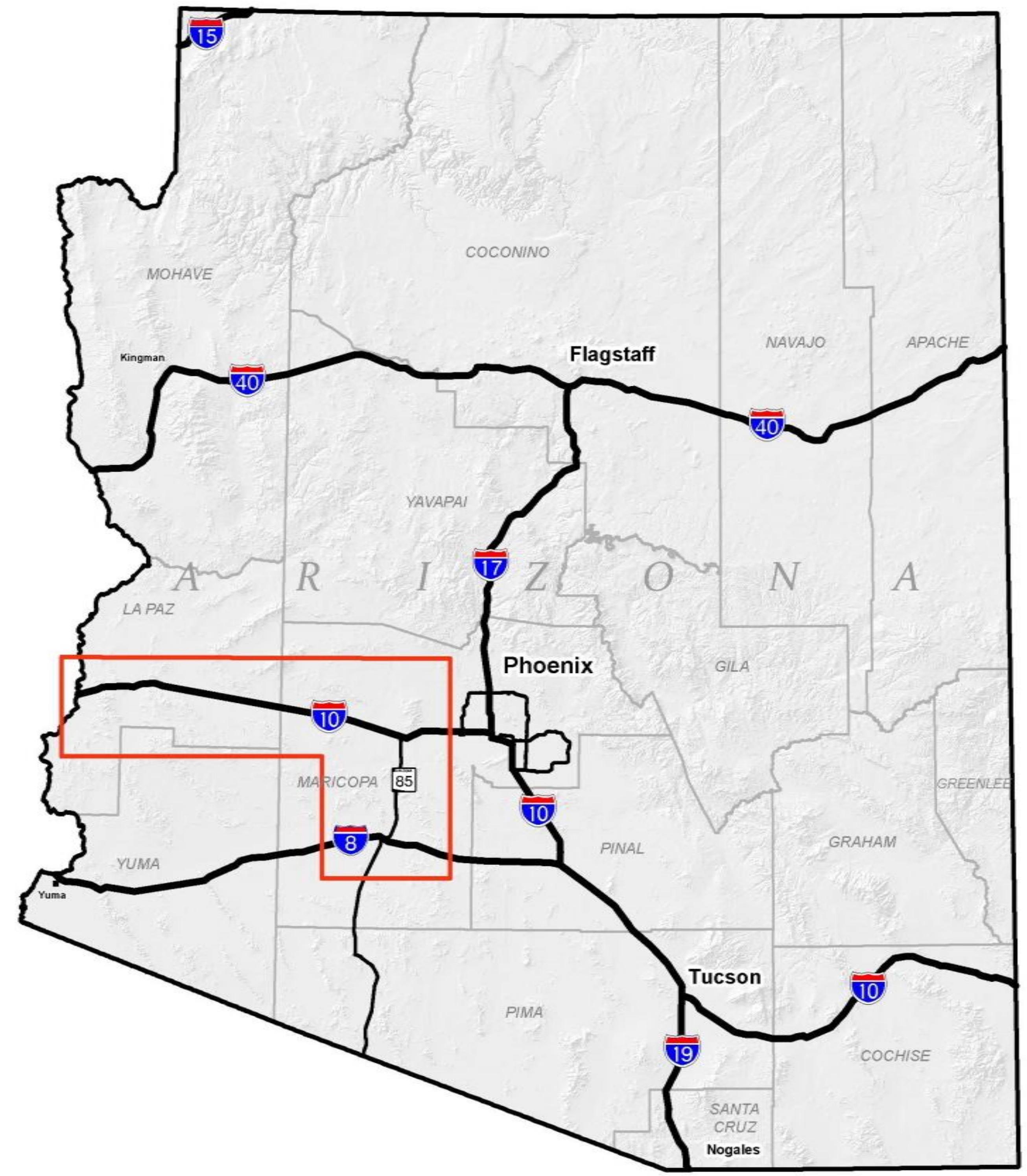
The third round (Round 3) of studies, initiated in Fall 2015, include:

- I-10: California State Line to SR 85 and SR 85: I-10 to I-8
- I-10: SR 202L to the New Mexico State Line
- SR 87/SR 260/SR 377: SR 202L to I-40
- US 60/US 70: SR 79 to US 191 and US 191: US 70 to SR 80
- US 60/US 93: Nevada State Line to SR 303L

The studies under this program will assess the overall health, or performance, of the states, strategic highways. The Corridor Profile Studies will identify candidate projects for consideration in the Multimodal Planning Divison's (MPD) Planning to Programming (P2P) project prioritization process, providing information to guide corridor-specific project selection and programming decisions.

I-10/ SR 85 from the California state line to I-8, depicted in **Figure 1**, is one of the strategic statewide corridors and the subject of this Corridor Profile Study (**Round 3**).

Figure 1: Corridor Study Area



1.1. Corridor Study Purpose

The purpose of the I-10/ SR 85 Corridor Profile Study is to measure corridor performance to inform the development of strategic solutions that are cost-effective and account for potential risks. This purpose can be accomplished by following the established by previous corridor profile studies to:

- Inventory past improvement recommendations.
- Assess the existing performance based on quantifiable performance measures.
- Define goals and objectives for the future of the corridor
- Propose various solutions to improve corridor performance.
- Identify specific projects that can provide quantifiable benefits in relation to the performance measures.
- Prioritize the projects for future implementation

1.2 Corridor Study Goals and Objectives

The objective of this study is to identify a recommended set of potential projects for consideration in future construction programs, derived from a transparent, defensible, logical, and replicable process. The I-10/SR 85 Corridor Profile Study will define solutions and improvements for I-10/SR 85 that can be evaluated and ranked to determine which investments offer the greatest benefit to the corridor in terms of enhancing performance.

The following goals have been identified as the outcome of this study:

- Link project decision-making and investments on key corridors to strategic goals
- Develop solutions that address identified corridor needs based on measured performance
- Prioritize improvements that cost-effectively preserve, modernize, and expand transportation infrastructure

1.3 Working Paper 2 Overview

The objective of Working Paper # 2 is to assess the health of the corridor based on a performance system that can be applied to other corridors and allow the comparison of corridor health across corridors. The assessment of corridor needs (based on the performance system) will occur in a later working paper.

1.4 Corridor Overview

The I-10/SR 85 provides an important connection from Southern California to economic and recreational opportunities in Central Arizona and other destinations to the east. I-10 is generally a 4-lane divided freeway from the California border to SR 85 while SR 85 is a two-lane highway facility connecting I-10 to I-8. Together, the two roadways provide a passage from Southern California to Tucson while bypassing the Metropolitan Phoenix Area.

Plans have been made to upgrade SR 85 to a freeway facility between I-10 and I-8, which will greatly increase accessibility for both freight and tourism travel. I-10 between California and SR 85 is a direct connection between Phoenix and Los Angeles. Similarly, SR 85 between I-10 and I-8 is both a bypass route for freight traffic wishing to avoid the Phoenix Area and a major corridor in the linkage between Phoenix and San Diego. Therefore, the entire corridor is considered an important connection for both freight and tourism travel in the state.

Another major consideration for this corridor is the role it plays in the CANAMEX system. CANAMEX is the name commonly used to describe a planned future roadway system that will connect Mexico to Canada through several U.S. states, Arizona included. The CANAMEX Corridor in Arizona is designated along I-10 from the Tucson area to I-8, west to SR 85, then along SR 85 between I-8 and I-10 to Wickenburg Road. From there the corridor will travel north through Wickenburg, eventually to Las Vegas and beyond. The I-10/SR 85 corridor constitutes a large portion of the Arizona CANAMEX system, making it an important route in interstate and international travel.

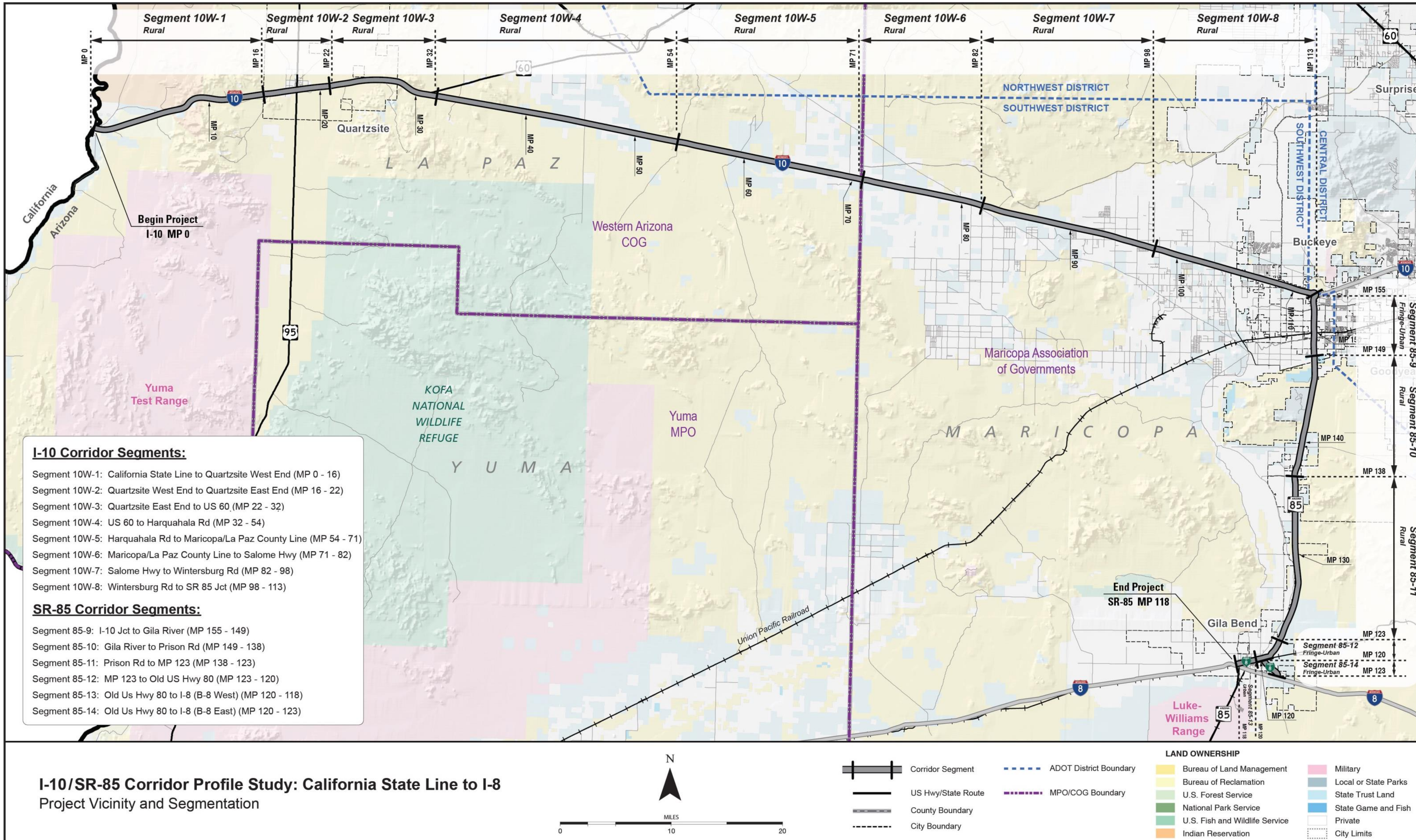
1.5 Study Location and Corridor Segments

The I-10/SR 85 extends from the California State Line (MP 0) to SR 85 (MP 113) on I-10 and from I-10(MP 155) to I-8 (MP 118) on SR 85, which is approximately 150 miles. This corridor provides a bypass to downtown Phoenix from the south and west and connects I-10 and I-8. Identification of highway segments was determined based on roadway, traffic and jurisdictional characteristics to allow for the appropriate level of analysis for similar operating environments between segments. Fourteen segments have been identified as described in **Table 1** and illustrated in **Figure 2**. Based on team input and data collection, the segment limits may be adjusted as the study progresses. Initial segmentation was completed as shown in **Table 1**.

Table 1: I-10/SR 85 Corridor Segments and Descriptions

Segment	Begin	End	Begin MP	End MP	Length (mi)	Thru Lanes	2014 AADT (VPD)	Character Description
10W-1	California State Line	West Quartzsite	I-10 MP 0	I-10 MP 16	16	2 EB, 2 WB	16,000 - 20,000	This segment includes the Ehrenberg Port of Entry at milepost 3.8 which is a required checkpoint for commercial traffic entering Arizona. It is a four-lane divided section that has been classified as a rural operating environment.
10W-2	West Quartzsite	East Quartzsite	I-10 MP 16	I-10 MP 22	6	2 EB, 2 WB	16,000 - 21,600	This segment passes through Quartzsite and includes the I-10/SR 95 junction. It is six miles long and sustains consistent traffic volumes on a four-lane section.
10W-3	East Quartzsite	Jct US 60	I-10 MP 22	I-10 MP 32	10	2 EB, 2 WB	18,500 - 21,600	This segment is 10 miles long between the eastern border of Quartzite and the I-10/US 60 junction. It has been classified as a rural environment and it is mostly flat with traffic volumes 16,000 to over 20,000 vehicles per day.
10W-4	Junction US 60	Harquehala Rd	I-10 MP 32	I-10 MP 54	22	2 EB, 2 WB	20,400 - 21,500	This segment is 22 miles long between the US 60 junction and Harquehala Road. It is a four-lane section that has been classified as a rural environment.
10W-5	Harquehala Rd	La Paz/Maricopa County Border	I-10 MP 54	I-10 MP 71	17	2 EB, 2 WB	19,100 - 21,500	This segment runs from Eastern La Paz County to the Maricopa County border. It is 17 miles long and has been classified as a rural environment.
10W-6	La Paz/Maricopa County Border	Salome Rd	I-10 MP 71	I-10 MP 82	11	2 EB, 2 WB	19,100 - 20,500	This segment is 11 miles long, includes two general purpose lanes in each direction, and has been classified as a rural environment.
10W-7	Salome Rd	Wintersburg Rd	I-10 MP 82	I-10 MP 98	16	2 EB, 2 WB	20,500 - 25,500	This segment includes the Town of Tonopah. It is a four-lane section where traffic volumes begin to increase towards the east.
10W-8	Wintersburg Rd	I-10/SR 85 Interchange	I-10 MP 98	I-10 MP 113, SR 85 MP 155	15	2 EB, 2 WB	25,500 - 32,200	This segment is 15 miles long and includes the portion of I-10 that serves as a principal evacuation route for the Palo Verde Nuclear Generating Station, which is located six miles south of I-10. It is a four-lane section, it has been classified as a rural environment, and it has over 25,000 vehicles per day.
85-9	I-10/SR 85 Interchange	Gila River (MP 149)	I-10 MP 113, SR 85 MP 155	SR 85 MP 149	6	2 EB, 2 WB	15,100 - 13,700	This segment is a four-lane section that connects I-10 south to the Gila River. It passes through the western portion on the Town of Buckeye and has been classified as a fringe urban operating environment.
85-10	Gila River (MP 149)	Patterson Rd/ Prison Access	SR 85 MP 149	SR 85 MP 138	11	2 NB, 2 SB	15,100 - 8,900	This segment is 11 miles long and is a four-lane divided section. The southern limit provides direct access to the Arizona State Prison complex.
85-11	Patterson Rd/ Prison Access	Gila Bend Limits	SR 85 MP 138	SR 85 MP 123	15	2 NB, 2 SB	8,900 - 10,600	This segment starts at the southern limits of Buckeye and ends at approximately the northern limits of Gila Bend. It is a four-lane divided section and has been classified as a rural environment.
85-12	Gila Bend Limits	Jct B-8	SR 85 MP 123	SR 85 MP 120	3	2 NB, 2 SB	10,600 - 12,000	This segment transitions to one lane in each direction on a non-divided section. The speed limit drops entering into Gila Bend and this segment has been classified as fringe urban.
85-13	Jct B-8	Jct I-8 WB	SR 85 MP 120	B-8 MP 118	2	2 EB, 2 WB, 1 LT	9,300 – 11,500	This segment starts at SR 85 and transitions onto B-8 through Gila Bend. It is a five-lane arterial section with a dedicated left-turn lane. This segment provides direct access to commercial businesses within Gila Bend and acts as an arterial roadway.
85-14	Jct B-8	Jct I-8 EB	SR 85 MP 120	B-8 MP 123	3	1 NB, 1 SB	12,000 – 12,100	This segment starts at SR 85 and transitions onto S Butterfield Trail. It is a two lane non-divided section that provides access to I-8 without going through Gila Bend. Various commercial businesses have direct access to this segment as well.

Figure 2: I-10/SR 85 Corridor Segmentation



2. PERFORMANCE FRAMEWORK

2.1. Performance Framework Overview

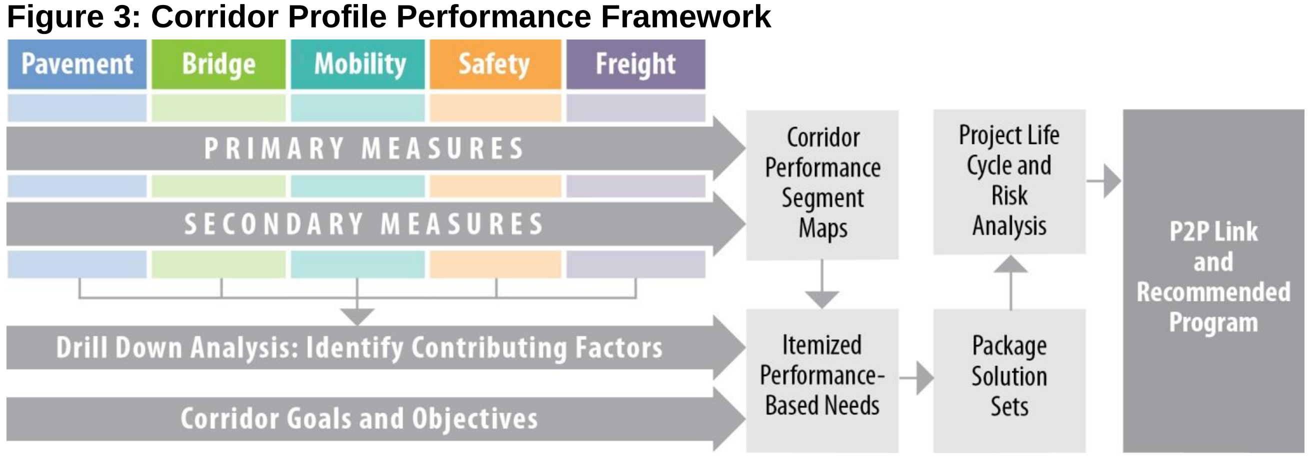
An objective of the ADOT Corridor Profile Studies is to use a performance-based process to define baseline corridor performance, diagnose corridor needs and deficiencies, develop corridor solutions, and prioritize strategic corridor investments. In support of this study objective, a framework for the performance-based process was developed through a collaborative process involving ADOT and the consultant teams for all active Corridor Profile Studies. Changes made to the methodologies between this and the previous round of corridor profile studies are described in Appendix A. In the performance framework illustrated in Figure 3, baseline performance is evaluated using primary and secondary performance measures to define the health of the corridor and identify locations that warrant further diagnostic investigation to define needs and deficiencies.

Needs and deficiencies are defined as the difference in baseline corridor performance compared to established performance goals and objectives. Corridor improvements and strategies are characterized in the ADOT transportation plan as investment options for preserving, modernizing, and expanding corridor infrastructure to improve corridor performance. Improvement priorities are evaluated using ADOT's Planning to Programming (P2P) Link processes.

Five performance areas were defined to guide the performance-based corridor analyses. The five performance areas include:

- Pavement performance
- Bridge performance
- Mobility performance
- Safety performance
- Freight performance

Figure 3: Corridor Profile Performance Framework



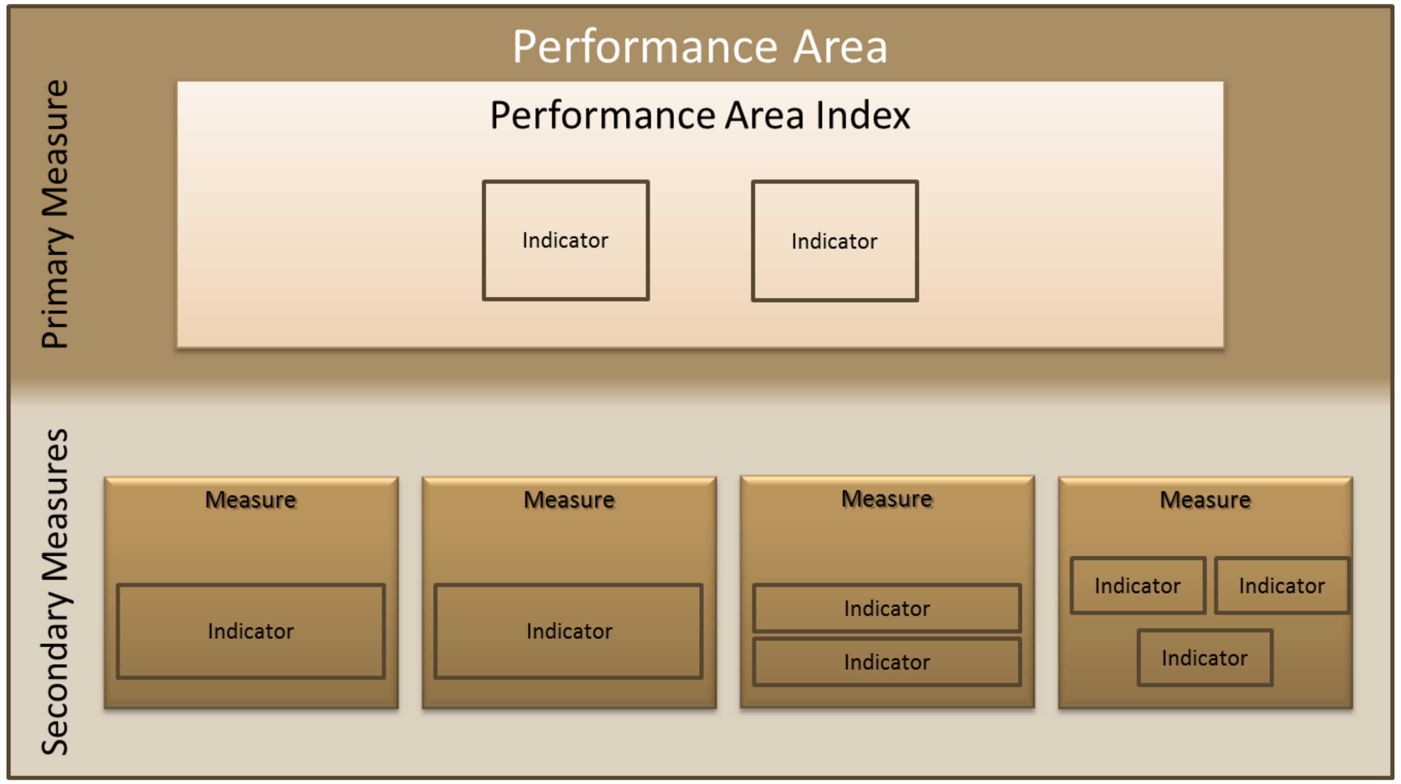
These performance areas reflect the seven *Moving Ahead for Progress in the 21st Century* (MAP-21) national performance goals which are listed below.

- Safety: To achieve a significant reduction in traffic fatalities and serious injuries on all public roads
- Infrastructure condition: To maintain the highway infrastructure asset system in a state of good repair
- Congestion reduction: To achieve a significant reduction in congestion on the National Highway System
- System reliability: To improve the efficiency of the surface transportation system
- Freight movement and economic vitality: To improve the national freight network, strengthen the ability of rural communities to access national and international trade markets, and support regional economic development
- Environmental sustainability: To enhance the performance of the transportation system while protecting and enhancing the natural environment
- Reduced project delivery delays: To reduce project costs, promote jobs and the economy, and expedite the movement of people and goods by accelerating project completion

The above national performance goals also were considered in the development of ADOT's P2P Link for linking transportation planning to capital improvement programming and project delivery. Because P2P Link requires the preparation of annual transportation system performance reports using the five performance areas adopted for the ADOT Corridor Profile Studies, consistency is achieved in the performance measures used for various ADOT analysis processes.

A generalized framework for each performance area is illustrated in **Figure 4**.

Figure 4: Performance Area Measures



The guidelines for performance measure development are listed below:

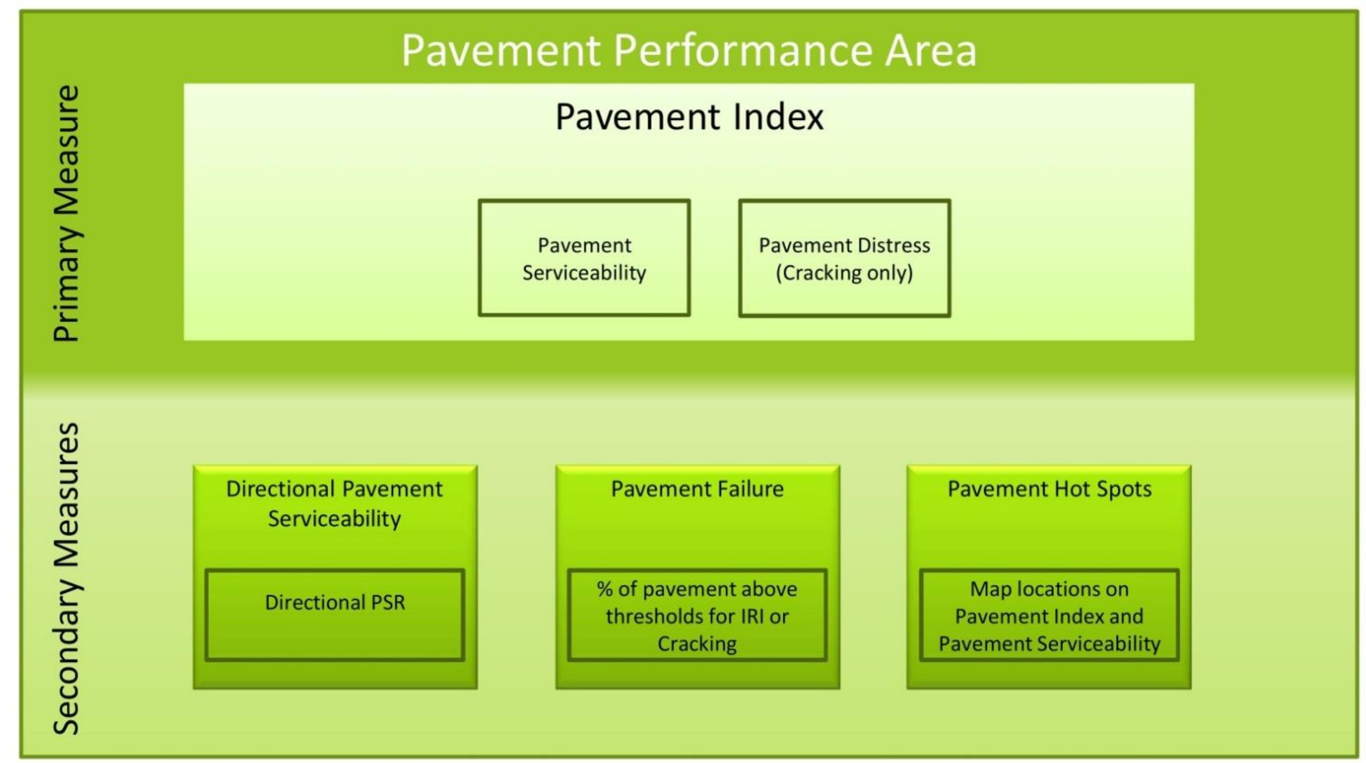
- Indicators (or performance measures) for each performance area should be developed for relatively homogeneous corridor segments.
- Performance measures for each performance area should be tiered, consisting of primary measure(s) and secondary measure(s).
- Primary and secondary measures will assist in identifying those corridor segments that warrant in-depth diagnostic analyses to identify performance-based needs and a range of corrective actions known as solution sets.
- One or more primary performance measures should be used to develop a Performance Area Index to communicate the overall health of a corridor and its segments for each performance area. The Performance Index should be a single numerical index that is quantifiable, repeatable, scalable, and capable of being mapped. Primary performance measures should be transformed into a performance index using mathematical or statistical methods to combine one or more data fields from an available ADOT database.
- The principal use of the one or more secondary performance measures should be to provide additional details to define corridor locations that warrant further diagnostic analysis. Secondary performance measures may include the individual measures used to calculate the Performance Index and/or "hot spot" features.

3. CORRIDOR HEALTH

3.1. Pavement Performance Area

The Pavement Performance Area consists of a primary measure (Pavement Index) and three secondary measures, as shown in **Figure 5**, to assess the condition of the existing pavement along the corridor. The performance system was developed in collaboration with ADOT Materials Group. The results of the Pavement Performance Area are presented in Section 3.1.3. A detailed methodology for calculating the performance measures is provided in Appendix B.

Figure 5: Pavement Performance Area



For the Pavement Performance Area, only mainline pavement was included in the calculation. Pavement condition data for ramps, frontage roads, crossroads, etc. was not included. Detailed information related to the calculations for the Pavement Performance area is included in Appendix B.

3.1.1 Primary Measure

The Pavement Index is calculated based on the use of two pavement condition ratings from the ADOT Pavement Database. The two ratings are the International Roughness Index (IRI) and the Cracking Rating (CR). The calculation of the Pavement Index uses a combination of these two ratings. These two ratings were used for the primary measure since they represent the data used by ADOT Materials Group to assess the need for pavement rehabilitation.

The IRI is a measurement of the pavement roughness based on field-measured longitudinal roadway profiles. To facilitate the calculation of the index, the IRI rating was converted to a Pavement Serviceability Rating (PSR) using the following equation:

$$PSR = 5 * e^{-0.0038*IRI}$$

The Cracking Rating (CR) is a measurement of the amount of surface cracking based on a field-measured area of 1,000 square feet that serves as a sample for each mile. To facilitate the calculation of the index, the Cracking Rating was converted to a Pavement Distress Index (PDI) using the following equation:

$$PDI = 5 - (0.345 * C^{0.66})$$

Both the PSR and PDI use a 0 to 5 scale with 0 representing the lowest performance and 5 representing the highest performance. The performance thresholds shown in **Table 2** below were used for the PSR and PDI.

Table 2: PSR and PDI Performance Thresholds

Condition	Interstates		Non-Interstates	
	IRI (PSR)	Cracking (PDI)	IRI (PSR)	Cracking (PDI)
Good	<75 (>3.75)	<7 (>3.75)	<94 (>3.50)	<9 (>3.50)
Fair	75 - 117 (3.20 - 3.75)	7 - 12 (3.22 - 3.75)	94 - 142 (2.90 - 3.50)	9 - 15 (2.90 - 3.50)
Poor	>117 (<3.20)	>12 (<3.22)	>142 (<2.90)	>15 (<2.90)

The PSR and PDI are calculated for each 1-mile section of roadway. If the PSR or PDI falls into a poor rating (see table above) for a 1-mile section, then the score for that 1-mile section is entirely (100%) based on the lower score (either PSR or PDI). If neither PSR or PDI fall into a poor rating for a 1-mile section, then the score for that 1-mile section is based on a combination of the lower rating (70% weight) and the higher rating (30% weight). The end result is a score between 0 and 5 for each direction of travel of each mile of roadway based on a combination of both the PSR and the PDI.

The Pavement Index for each segment is a weighted average of the directional ratings based on the number of travel lanes. Therefore, the condition of a section with more travel lanes will have a greater influence on the resulting segment Pavement Index than a section with fewer travel lanes. The performance thresholds for the Pavement Index are as follows:

- Interstate Facilities:
  - Good: > 3.75
  - Fair: 3.20 – 3.75
  - Poor: < 3.20
- Non-Interstate Facilities:
  - Good: > 3.50
  - Fair: 2.90 – 3.50
  - Poor: < 2.90

3.1.2 Secondary Measures

Three secondary measures will be evaluated:

- Directional Pavement Serviceability
- Pavement Failure
- Pavement Hot Spots

Directional Pavement Serviceability

Similar to the Pavement Index, the Directional Pavement Serviceability is calculated as a weighted average (based on number of lanes) for each segment. However, this rating will only utilize the PSR and will be calculated separately for each direction of travel. The PSR uses a 0 to 5 scale with 0 representing the lowest performance and 5 representing the highest performance. The purpose of this secondary measure is to assess the condition of the pavement in each direction of travel. The thresholds for the Directional Pavement Serviceability are as follows:

- Interstates:
  - Good: > 3.75
  - Fair: 3.20 – 3.75
  - Poor: < 3.20
- Non-Interstates:
  - Good: > 3.50
  - Fair: 2.90 – 3.50
  - Poor: < 2.90

Pavement Failure

This secondary measure calculates the percentage of pavement area for each segment that is rated above the failure thresholds for IRI or Cracking, as established by ADOT Materials Group (IRI > 105 or Cracking > 15 for Interstates, and IRI > 142 or Cracking > 15 for Non-Interstates). The pavement area within each segment that has been identified in poor condition will be totaled and divided by the total pavement area for the segment to calculate the percentage of pavement area in poor condition for each segment. Based on the data from the I-17, I-19, I-40, I-8, and SR 95 corridors, the thresholds for the Pavement Failure are as follows:

- Above average performance: < 5%
- Average performance: 5% - 20%
- Below average performance: > 20%

Pavement Hot Spots

A pavement "hot spot" exists where a given 1-mile section of roadway rates as being in "poor" condition. For the Pavement Index map, the hot spots are based on either the IRI rating or the Cracking rating, as described above for the Pavement Failure Rating. For the Directional Pavement Serviceability map, the hot spots are only based on the IRI rating, as described above for the Pavement Failure Rating. This measure is mapped for graphical display purposes but is not included in the Pavement Performance Area rating calculations.

3.1.3 I-10/SR 85 Pavement Performance

The Pavement Index and secondary performance measures were calculated for the I-10/SR 85 corridor as described above. The pavement measures were calculated using pavement condition data provided by ADOT for the timeframe from 2014.The Pavement Index provides a top-level assessment of the pavement condition for the corridor and for each segment. The Directional PSR and the Pavement Failure measures provide more detailed information to assess the pavement condition for each segment. The resulting scores are shown in **Table 3**.

The results for the Pavement Index and the secondary measures are shown in **Figure 6, Figure 7,** and **Figure 8.**

Based on the results of this analysis, the following observations could be made:

- Overall, based on the weighted average of the Pavement Index, the pavement is in "good" condition
- According to the Pavement Index, nearly all of the Pavement is in "good" condition
- There are several failure hot spots along the corridor in segments 1, 4, 6, 8, 10, 11 and 12.
- 27% of the pavement in segment 4 and 22% of the pavement in segment 11 is considered to be in failure.
- The eastbound and westbound pavements are mostly "good" in condition, with the exception of a "fair" pavement PSR in segments 4, 6, 8, and 12.
- Segment 4 has highest percentage of pavement in "poor" condition, and both directions of pavement are in "fair" condition.

Table 3: Pavement Performance Summary

Segment	Segment Length (miles)	Pavement Performance Area			
		Pavement Index	Directional PSR		% Pavement Failure
			WB/NB	EB/SB	
10W-1	16	3.76	3.96	3.93	13%
10W-2	6	3.61	3.87	4.06	0%
10W-3	10	3.90	3.88	3.97	0%
10W-4	22	3.76	3.52	3.74	27%
10W-5	17	4.37	4.22	4.16	0%
10W-6	11	3.85	3.55	3.68	18%
10W-7	16	3.95	3.81	3.94	0%
10W-8	15	3.95	3.67	3.80	13%
85-9	6	4.01	3.85	3.63	0%
85-10	11	3.83	3.82	4.11	14%
85-11	15	3.80	4.35	3.78	22%
85-12	3	3.32	3.42	3.21	17%
85-13	2	No Data Available			
85-14	3	No Data Available			
Weighted Average		3.93			

Good/ Above Average Performance	> 3.75 (3.5)	> 3.75 (3.5)	< 5%
Fair/ Average Performance	3.20 – 3.75 (2.9-3.5)	3.20 – 3.75 (2.9-3.5)	5% - 20%
Poor/ Below Average Performance	< 3.20 (2.9)	< 3.20 (2.9)	> 20%

Figure 6: Pavement Index

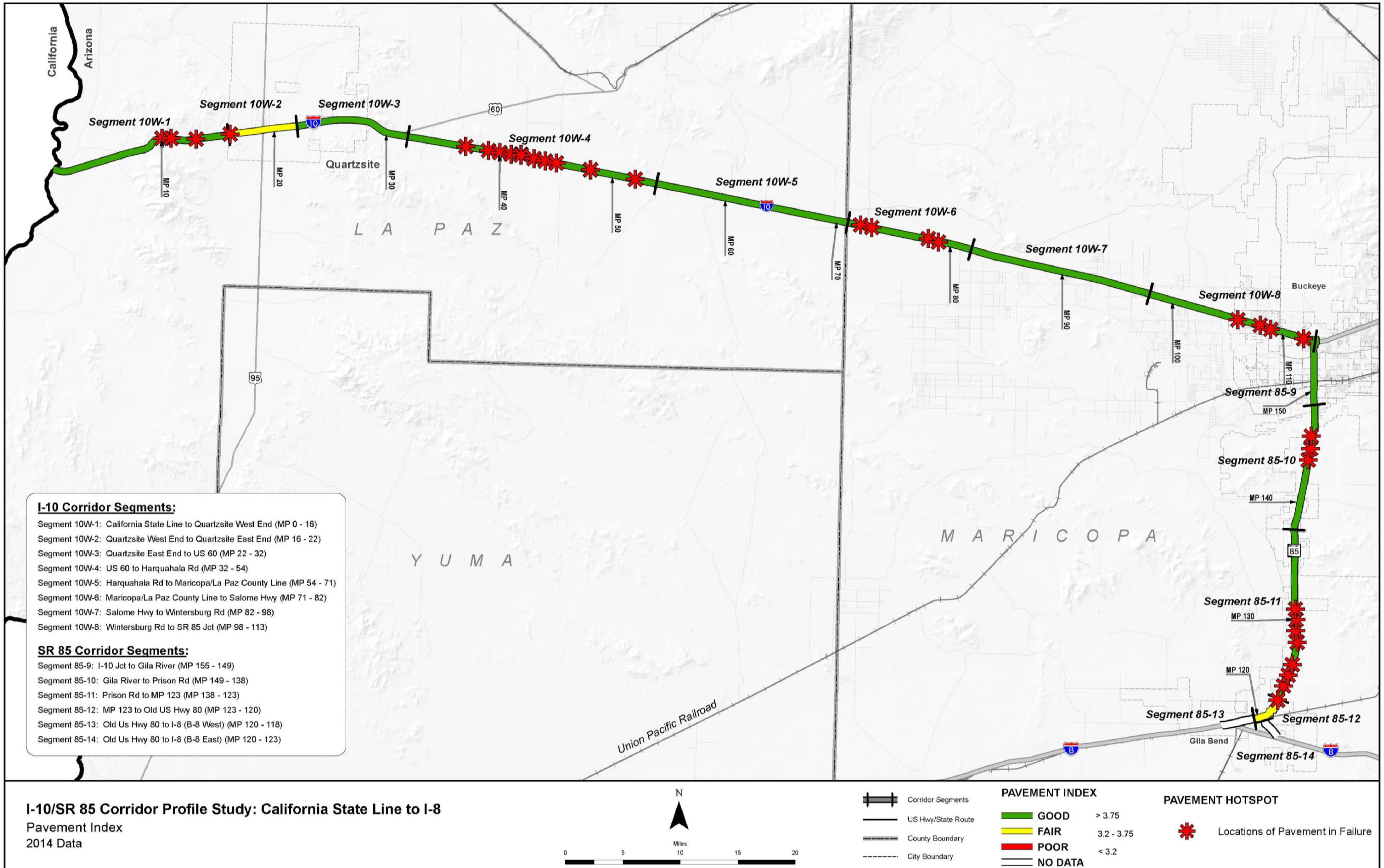


Figure 7: Directional Pavement Serviceability

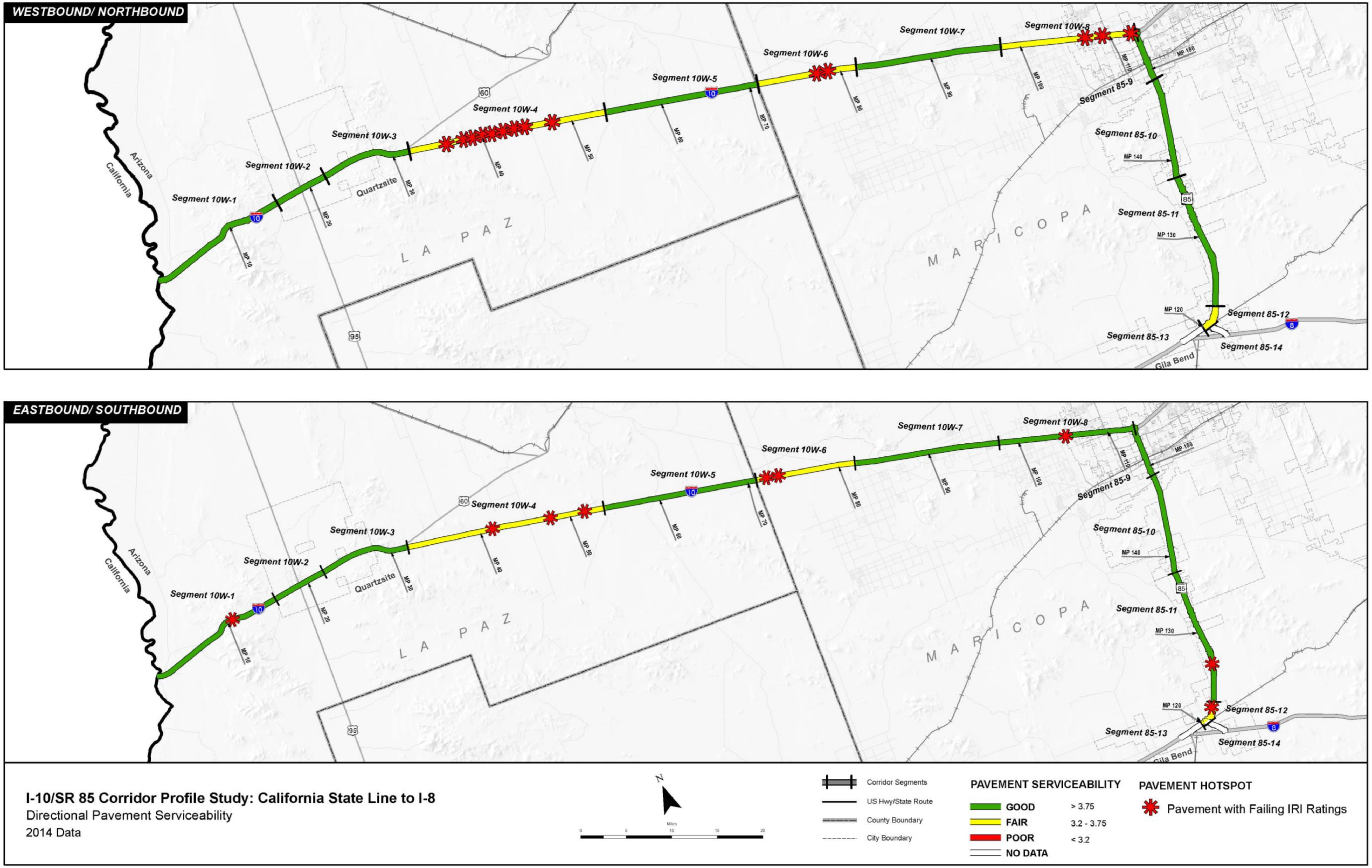
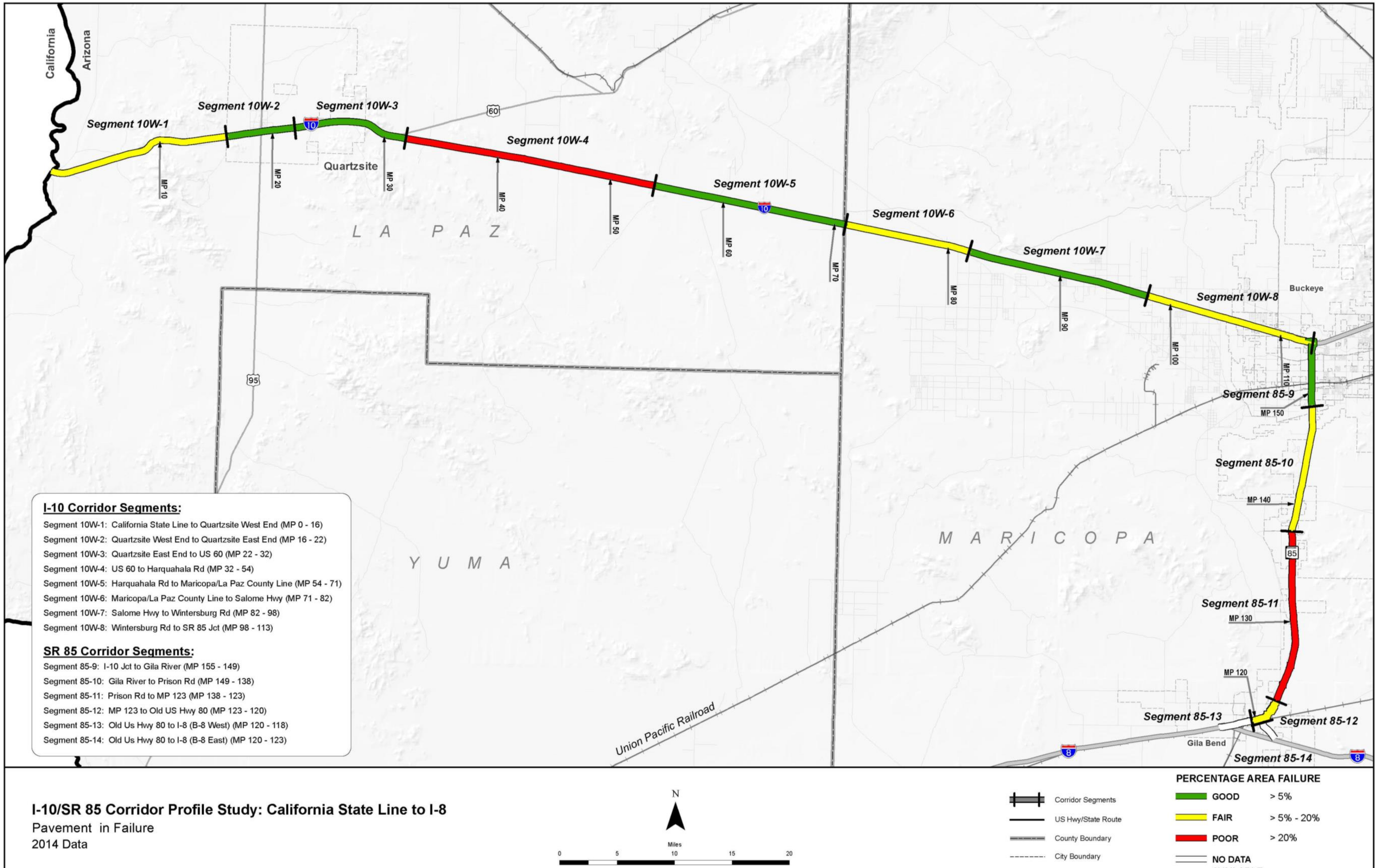


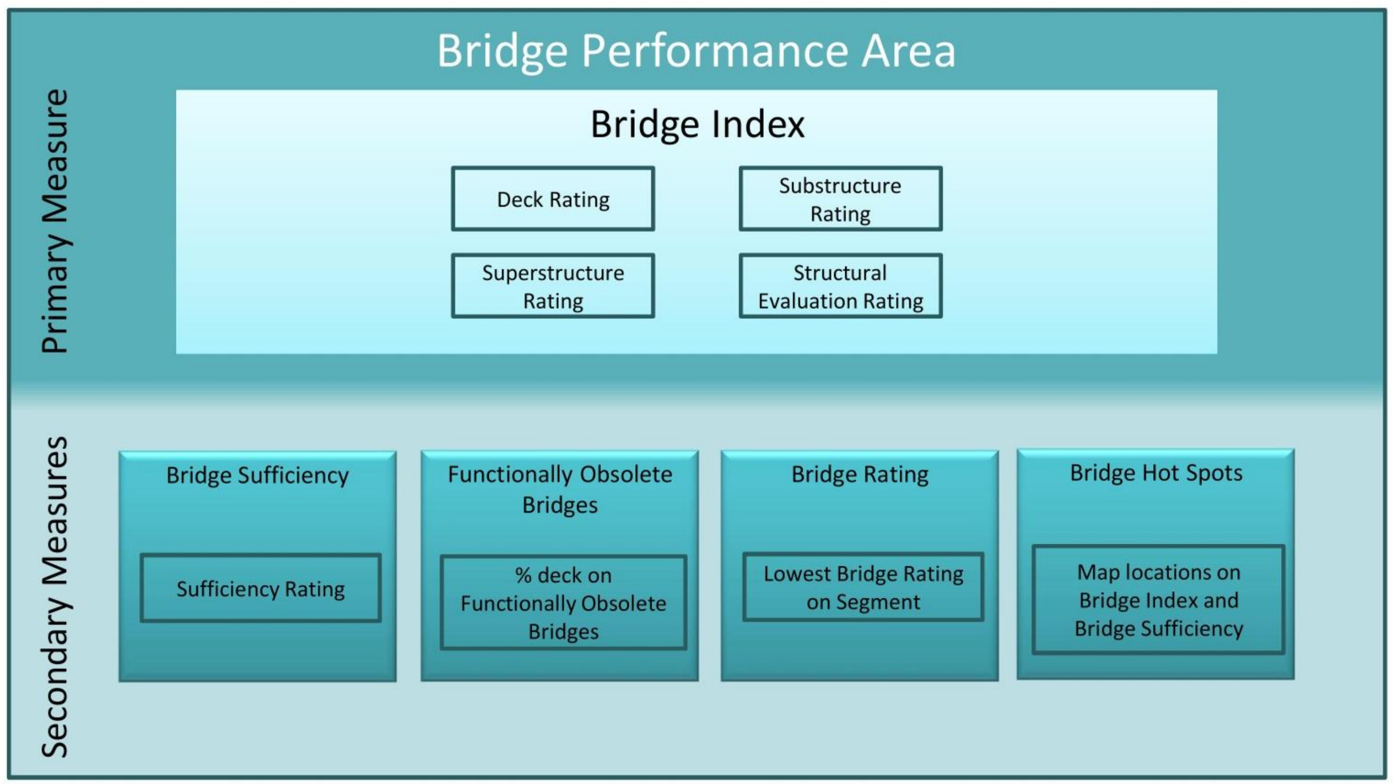
Figure 8: Pavement Failure



3.2. Bridge Performance Area

The Bridge Performance Area consists of a primary measure (Bridge Index) and four secondary measures, as shown in **Figure 9**, to assess the condition of the existing bridges along the corridor. The performance system was developed in collaboration with ADOT Bridge Group. The results of the Bridge Performance Area are presented in Section 3.2.3. A detailed methodology for calculating the performance measures is provided in Appendix B.

Figure 9: Bridge Performance Area



For the Bridge Performance Area, only bridges that carry mainline traffic or bridges that cross the mainline were included in the calculation. Bridges that do not carry mainline traffic or do not cross the mainline were not included. Detailed information related to the calculations for the Bridge Performance area is included in Appendix B.

3.2.1 Primary Measure

The Bridge Index is calculated based on the use of four bridge condition ratings from the ADOT Bridge Database, also known as the Arizona Bridge Information and Storage System (ABISS). The four ratings include the Deck Rating, Substructure Rating, Superstructure Rating, and Structural Evaluation Rating. These ratings are based on inspection reports and are used to establish the structural adequacy of the bridge. The condition of each individual bridge is established by using the lowest of these four ratings. The use of these ratings, and the use of the lowest rating, is consistent with the approach used by ADOT Bridge Group to assess the need for bridge rehabilitation.

Each of the four condition ratings uses a 0 to 9 scale with 0 representing the lowest performance and 9 representing the highest performance. As defined by ADOT Bridge Group, a rating of 7 or above represents “good” performance, a rating of 5 or 6 represents “fair” performance, and a rating of 4 or below represents “poor” performance.

In order to report the Bridge Index for each corridor segment, the Bridge Index for each segment is a weighted average condition rating based on the deck area for each bridge. Therefore, the condition of a larger bridge will have a greater influence on the resulting segment Bridge Index than a smaller bridge. The resulting Bridge Index is based on a 0 to 9 scale with 0 representing the lowest performance and 9 representing the highest performance. The performance thresholds for the Bridge Index are as follows:

- Good: > 6.5
- Fair: 5.0 – 6.5
- Poor: < 5.0

3.2.2 Secondary Measures

Four secondary measures will be evaluated:

- Bridge Sufficiency Rating
- Functionally Obsolete Bridges
- Bridge Rating
- Bridge Hot Spots

Bridge Sufficiency Rating

The Sufficiency Rating for each bridge is available from the ADOT Bridge Database. The Sufficiency Rating is calculated by using numerous factors to obtain a numeric value which is indicative of bridge sufficiency to remain in service. The result of this method is a percentage in which 100 percent would represent an entirely sufficient bridge and zero percent would represent an entirely insufficient or deficient bridge. The factors that contribute to the Sufficiency Rating include structural adequacy and safety, serviceability and functional obsolescence, and essentiality for public use. The Bridge Sufficiency rating was used as a secondary measure (instead of a primary measure) since it includes a broad range of information to assess the condition of the bridge including the amount of traffic and the length of detour, but does not directly relate to the structural adequacy of the bridge. Similar to the Bridge Index, the Bridge Sufficiency Rating is calculated as a weighted average (based on deck area) for each segment. The Sufficiency Rating is a scale of 0 to 100 with 0 representing the lowest performance and 100 representing the highest performance. The performance thresholds for the Bridge Sufficiency Rating are as follows:

- Good: > 80
- Fair: 50 – 80
- Poor: < 50

Bridge Rating

The Bridge Rating simply identifies the lowest bridge rating on each segment. This performance measure is not an average and therefore is not weighted based on the deck area. The Bridge Index identifies the lowest rating for each bridge, as described above. This secondary performance measure will simply identify the lowest rating on each segment. Each of the four condition ratings uses a 0 to 9 scale with 0 representing the lowest performance and 9 representing the highest performance. The performance thresholds for the Bridge Rating are as follows:

- Good: > 6
- Fair: 5 – 6
- Poor: < 5

Functionally Obsolete Bridges

Functionally Obsolete means that the design of a bridge is no longer functionally adequate for its current use, such as a lack of shoulders or the inability to handle current traffic volumes. Functionally Obsolete does not directly relate to the structural adequacy.

The percentage of deck area on functionally obsolete bridges is calculated for each segment. The deck area for each bridge within each segment that has been identified as functionally obsolete will be totaled and divided by the total deck area for the segment to calculate the percentage of deck area on functionally obsolete bridges for each segment. Based on the data from the I-17, I-19, I-40, I-8, and SR 95 corridors, the thresholds for the Functionally Obsolete Bridges are as follows:

- Above average performance < 12%
- Average performance: 12% - 40%
- Below average performance: > 40%

Bridge Hot Spots

A bridge "hot spot" exists where a given bridge has a bridge rating of 4 or lower or multiple ratings of 5. This measure is mapped for graphical display purposes but is not included in the Bridge Performance Area rating calculations.

3.2.3 I-10/SR 85 Bridge Performance

The Bridge Index and Secondary Performance Measures were calculated for the I-10/SR 85 corridor as described above. The bridge measures were calculated using bridge condition data provided by ADOT for the timeframe from 2012 to 2014. The Bridge Index provides a top-level assessment of the structural condition for the corridor and for each segment. The three secondary measures provide more detailed information to assess the bridge condition for each segment. The resulting scores are shown in **Table 4**.

The results for the Bridge Index and secondary measures are shown in **Figure 10**, **Figure 11**, **Figure 12**, and **Figure 13**.

Based on the results of this analysis, the following observations could be made:

- Overall, based on the weighted average of the Bridge Index the corridor is performing in a "fair" manner. Over half of the segments are in "fair" condition, while there are only 5 segments performing in "good" condition.
- There are no bridges designated as structurally deficient along the corridor.
- There are eight bridges with a rating of 5 along the corridor, none of which have multiple 5 ratings.
- There are no bridges with a sufficiency rating of "poor" in the corridor.
- Only 3 bridges rate as functionally obsolete throughout the entire corridor.
- There are no bridges located in segments 9 and 11.
- There are no bridge hot spots located throughout the entire corridor.

Table 4: Bridge Performance Summary

Segment	Segment Length (miles)	# of Bridges	Bridge Performance Area			
			Bridge Index	Bridge Sufficiency	Bridge Rating	% Functionally Obsolete Bridges
10W-1	16	5	5.11	67.26	5	5.83%
10W-2	6	6	5.92	95.30	5	9.02%
10W-3	10	2	6.00	87.89	6	36.76%
10W-4	22	9	6.50	97.22	5	0.00%
10W-5	17	6	6.48	98.35	6	0.00%
10W-6	11	2	7.00	97.41	7	0.00%
10W-7	16	6	6.25	97.70	6	0.00%
10W-8	15	10	6.71	96.12	5	0.00%
85-9	6	0	NO BRIDGES IN SEGMENT			
85-10	11	6	6.53	99.47	6	0.00%
85-11	15	0	NO BRIDGES IN SEGMENT			
85-12	3	1	5.00	83.40	5	0.00%
85-13	2	4	5.21	89.61	5	0.00%
85-14	3	2	6.57	92.55	5	0.00%
Weighted Average			6.25			

Good/ Above Average Performance	> 6.5	> 80	> 6	< 12%
Fair/ Average Performance	5.0 – 6.5	50 - 80	5 – 6	12% - 40%
Poor/ Below Average Performance	< 5.0	< 50	< 5	> 40 %

Figure 10: Bridge Index

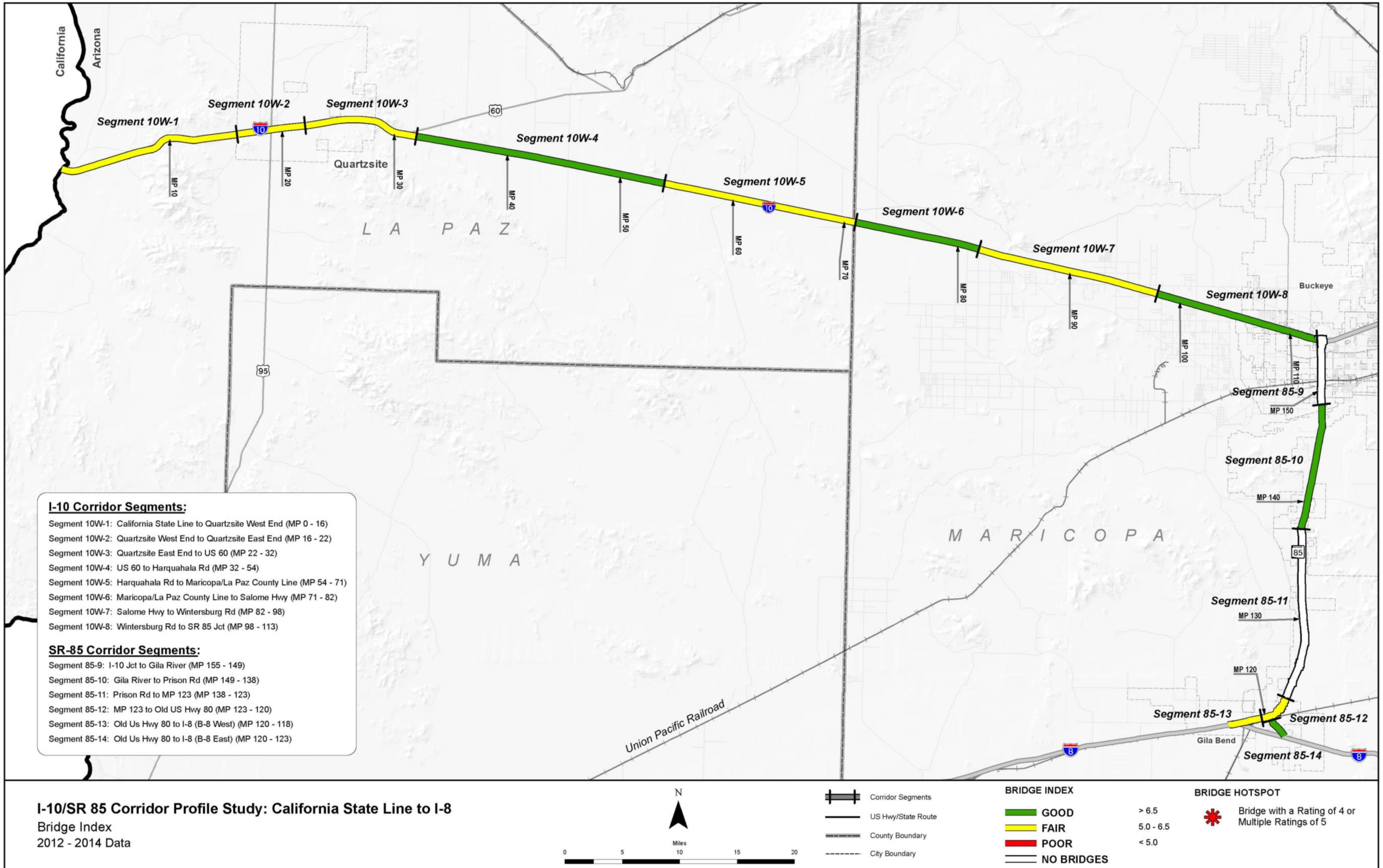


Figure 11: Bridge Sufficiency

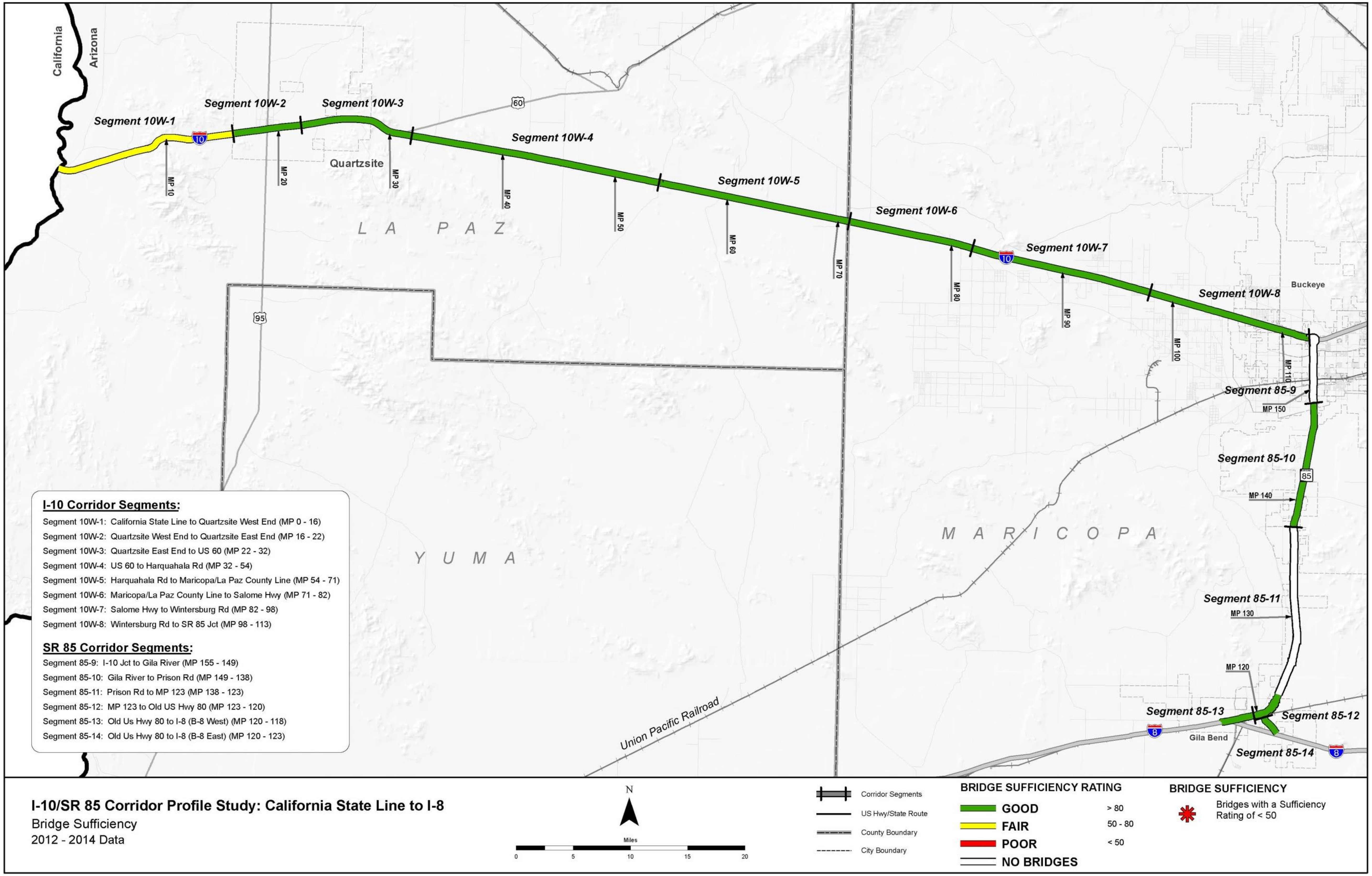


Figure 12: Bridge Rating

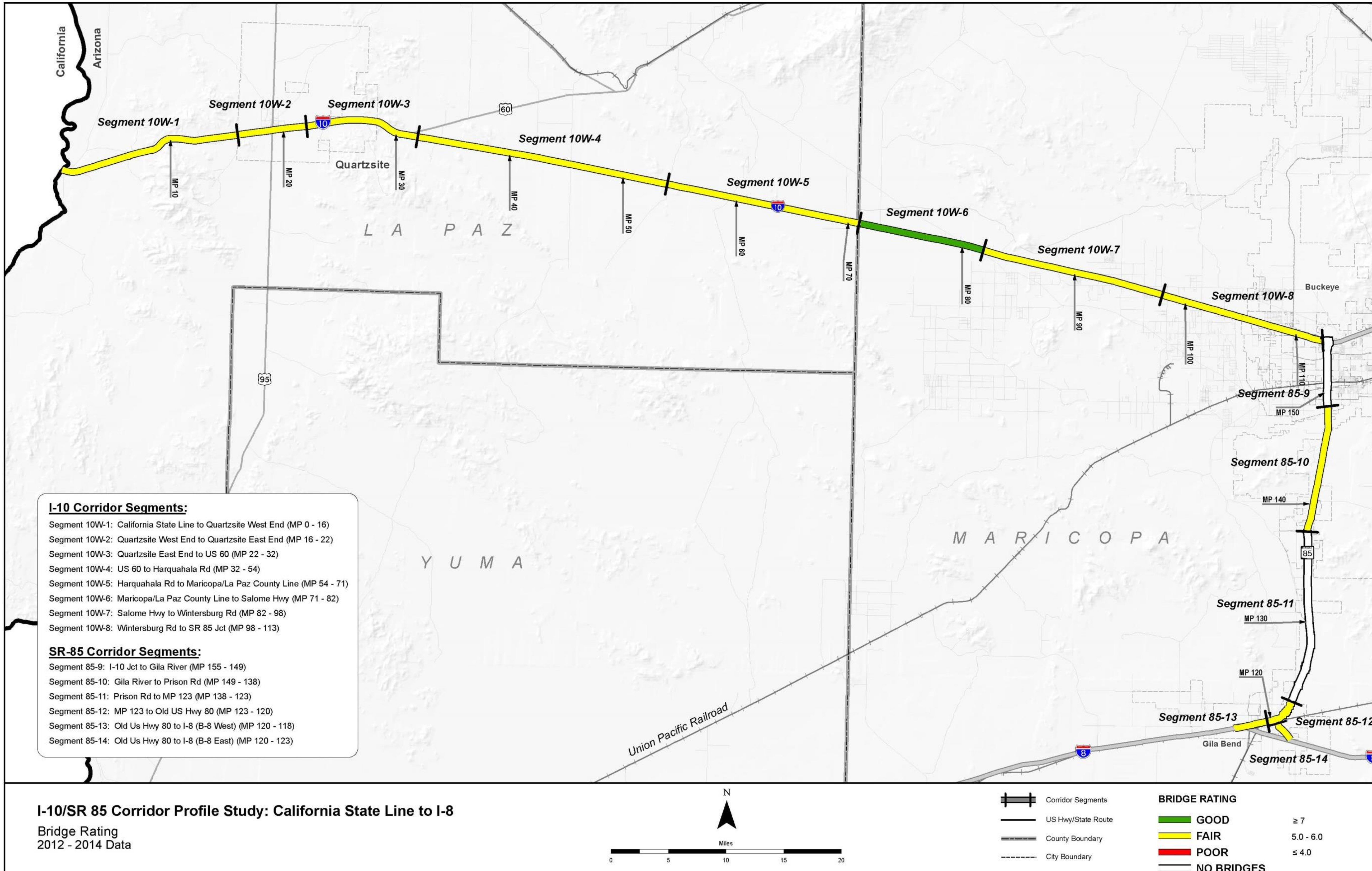
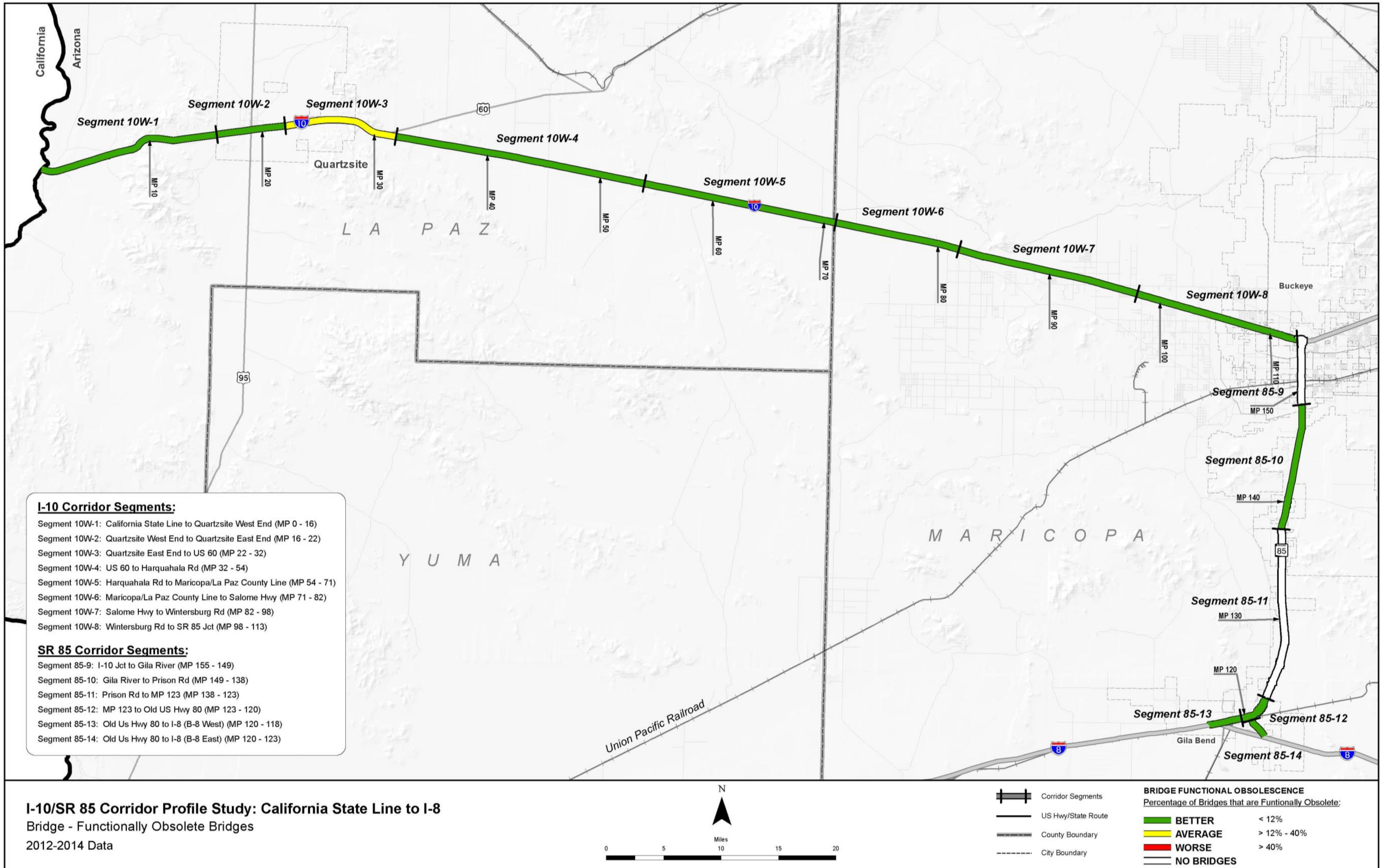


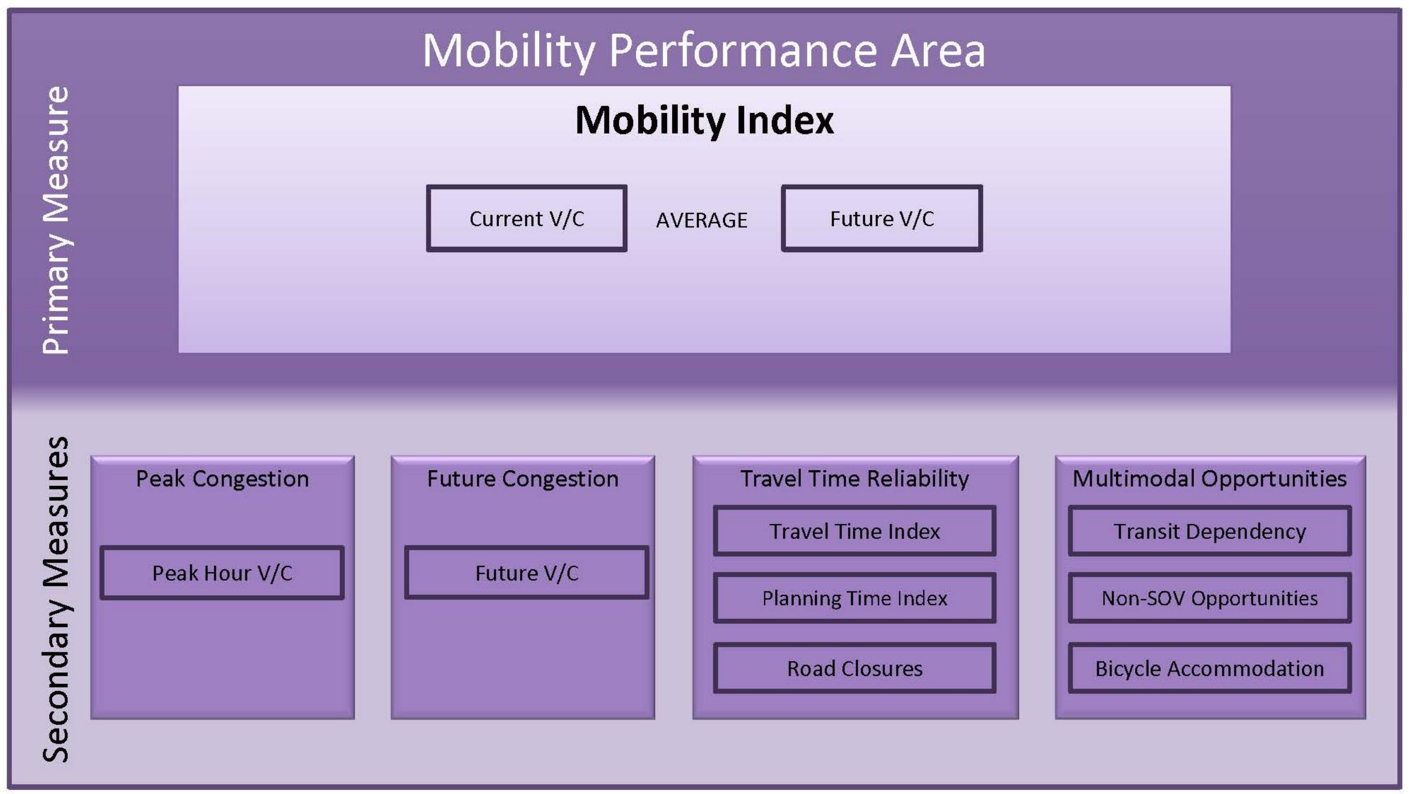
Figure 13: Functionally Obsolete Bridges



3.3. Mobility Performance Area

The Mobility Performance Area consists of a single primary measure (Mobility Index) and multiple secondary measures, as shown in **Figure 14**, to assess levels and types of congestion that occur along the I-10/SR 85 corridor using available data including annual average daily traffic (AADT), projected traffic volume growth from the Arizona Travel Demand Model (AZTDM), travel time, speed, and road closures. These datasets were used to develop primary and secondary measurements that were applied to I-10/SR 85 to determine the mobility performance of each corridor segment. The Mobility Performance Area was developed in collaboration with ADOT Multimodal Planning Division, which is involved in maintaining the AZTDM and associated travel data. Detailed information related to the calculations for the Mobility Performance Area is included in Appendix B of this Working Paper.

Figure 14: Mobility Performance Area



3.3.1 Primary Measure

The Mobility Index is an average of the current (2014) daily volume-to-capacity (V/C) ratio and the future (2035) daily V/C ratio for each segment of the corridor. V/C ratios are an indicator of levels of congestion. This measure compares the average AADT volume for a segment to the planning capacity of the segment as defined by the service volume for level of service E (LOS E). By using the average of the current and future year, this index measures the level of daily congestion that could occur in approximately ten years (2025) if no capacity improvements are made to the corridor.

Current Daily V/C Ratio

The current V/C ratio for each segment is calculated using the 2014 AADT volume and dividing that value by the service volume for LOS E, as calculated using the Highway Economic Requirements System (HERS) Procedures developed by the Federal Highway Administration (FHWA) for Estimating Highway Capacity. The HERS procedure provides the benefit of incorporating HCM 2010 methodologies while taking the context of the corridor into account. The capacity estimation procedures for various facility types are available including Freeways, Rural Two-Lane Highways, Multilane Highways, and Signalized Urban Sections.

AADT is obtained from the Highway Performance Monitoring System (HPMS) maintained by ADOT. Segment capacity is defined by the number of mainline lanes, shoulder widths, interrupted or uninterrupted flow facilities, terrain type, percent of truck traffic and the designated urban or rural environment.

Future Daily V/C Ratio

The future V/C ratio for each segment is calculated using the 2035 AADT volume and dividing that value by the service volume for LOS E, as estimated using the HERS procedure mentioned above. The 2035 AADT volumes are generated by applying an annual compound growth rate from the AZTDM to the 2014 AADT segment volume.

The scaling thresholds defined for the Mobility Index are based on the ADOT Roadway Design Guidelines, which define criteria for acceptable levels of service for the State Highway System. The following scaling thresholds are established for interstates in urban (and fringe urban) and rural environments.

Urban and Fringe Urban Environments
- Good (LOS A-C): V/C ≤ 0.71
- Fair (LOS D): V/C > 0.71 & ≤ 0.89
- Poor (LOS E-F): V/C > 0.89

Rural Environments
- Good (LOS A-B): V/C ≤ 0.56
- Fair (LOS C): V/C > 0.56 & ≤ 0.76
- Poor (LOS D-F): V/C > 0.76

3.3.2 Secondary Measures

The Mobility Performance Area has eight secondary measures:

- Peak Congestion – Current Peak Hour V/C
- Future Congestion – Future Daily V/C
- Travel Time Reliability – Directional Closures
- Travel Time Reliability – Directional Travel Time Index
- Travel Time Reliability – Directional Planning Time Index
- Multimodal Opportunities – Transit Dependency
- Multimodal Opportunities – Non-Single Occupancy Vehicle Trips
- Multimodal Opportunities – Bicycle Accommodation

Peak Congestion – Current Peak Hour V/C

Peak Congestion is defined as the peak hour V/C ratio for each direction of travel. The peak hour V/C is calculated by dividing the directional design hour volume (DHV) by the directional capacity. The DHV is calculated by applying a directional K factor to the directional daily AADT. K factors were obtained from HPMS.

The rating thresholds defined for the Peak Congestion secondary measure were developed based on the current ADOT Roadway Design Guidelines and are the same as the thresholds defined for the Mobility Index primary measure in Section 3.3.1.

Future Congestion – Future Daily V/C

Future Congestion is defined as the future (2035) daily V/C ratio. This measure is the same value used in the calculation of the Mobility Index.

The rating thresholds defined for the Future Congestion secondary measure are developed based on the current ADOT Roadway Design Guidelines and are the same as the thresholds defined for the Mobility Index.

Travel Time Reliability – Directional Closures

Closures that occurred at any point along I-10/SR 85 from 2010-2014 are documented in ADOT's Highway Condition Reporting System (HCRS) dataset. Directional Closures are defined as the average number of times a milepost is closed per mile per year on a given segment of the corridor in a specific direction of travel. A weighted average was applied to each closure that takes into account the distance over which a specific occurrence spans.

The scaling thresholds defined for the Directional Closures secondary measure are based on the average number of times a milepost was closed per mile per year based on data of the following eleven statewide significant corridors identified by ADOT: I-8, I-17, I-19, I-40, SR 93, SR 95, and parts of US 60, SR 85, SR 87, SR 191, SR 260, SR 277, and SR 377. The following scaling thresholds represent the average for closure occurrences across those corridors:

- Good: ≤ 0.22 occurrences per mile per year
- Fair: > 0.22 occurrences & ≤ 0.62 occurrences per mile per year
- Poor: > 0.62 occurrences per mile per year

Travel Time Reliability – Directional Travel Time Index

For purposes of this performance measure, the Travel Time Index (TTI) is the relationship of the posted speed limit to the mean peak hour speed. The TTI is affected most by recurring congestion. It is a comparison between the peak period speeds and free-flow conditions. Using the 2014 American Digital Cartography, Inc. HERE (formerly NAVTEQ) database provided by ADOT, which includes data received via Bluetooth technology from motorists traveling throughout the corridor, four time periods for each data point were collected throughout the day (AM Peak, Mid-Day Peak, PM Peak, and Off-peak). The highest value of the four time periods collected was defined as the TTI for that data point. The average TTI for each segment was calculated based on the average of the TTI values for the data points within that segment.

Based on national research and coordination with ADOT, the following thresholds were applied to the TTI:

Uninterrupted Flow Facilities

- Good: < 1.15
- Fair: 1.15 & 1.33
- Poor: ≥ 1.33

Interrupted Flow Facilities

- Good: < 1.30
- Fair: 1.30 & 2.00
- Poor: ≥ 2.00

Travel Time Reliability – Directional Planning Time Index

The Planning Time Index (PTI) represents the amount of time over and above the expected travel time that should be planned for to make an on-time trip on a consistent basis. It is a comparison between the 5th percentiles of the lowest mean speed to free-flow conditions. Similar to the TTI, the PTI utilizes 2014 HERE data provided by ADOT that is collected at each data point during four times of day (AM Peak, Mid-Day Peak, PM Peak, and Off-peak). The highest value of the four time periods collected was defined as the PTI for that data point. The average PTI for each segment was calculated based on the average of the PTI values for the data points within that segment.

Based on national research and coordination with ADOT, the following thresholds were applied to the PTI:

Uninterrupted Flow Facilities

- Good: < 1.30
- Fair: ≥ 1.30 & < 1.50
- Poor: ≥ 1.50

Interrupted Flow Facilities

- Good: < 3.00
- Fair: ≥ 3.00 & < 6.00
- Poor: ≥ 6.00

<u>Multimodal Opportunities – Transit Dependency</u>

Multimodal opportunities reflect the characteristics of the corridor in terms of likelihood to use alternate modes to the single occupancy vehicle for trips along the corridor. One of the potential alternate modes is transit.

Transit dependency was determined at the census tract level based on population characteristics associated with tracts within a one-mile radius of the corridor. Households that have zero or one automobile and households where the total income level is below the federally defined poverty level are considered transit dependent and therefore more likely to utilize transit if it is available. Based on 2010 U.S. Census data, tracts were analyzed within the corridor study area to determine if they accounted for more or fewer households with zero or one automobile or people in poverty than the statewide averages for those characteristics.

The rating thresholds defined for the overall transit dependency of each census tract are a combination of both transit dependent characteristics as follows:

- Good: Tracts with both zero/one automobile households and households in poverty percentages below the statewide average range
- Fair: Tracts with either zero/one vehicle household or households in poverty percentages within the statewide average range
- Poor: Tracts with both zero/one automobile households and households in poverty percentages above the statewide average range

<u>Multimodal Opportunities – Non-Single Occupancy Vehicle Trips</u>

Another alternate mode opportunity is non-single occupancy vehicle (SOV) trips, which represent the trips that are taken by vehicles carrying more than one person. The percentage of non-SOV trips in a corridor gives an indication of travel patterns along a section of roadway that could benefit from additional multimodal options in the future.

The rating thresholds defined for non-SOV trips are based on the percentage of non-SOV trips across the previously identified nine ADOT statewide significant corridors. The following thresholds represent statewide averages of non-SOV trips across those corridors:

- Good: ≥ 17% Non-SOV trips
- Fair: >11% & ≤ 17% Non-SOV trips
- Poor: < 11% Non-SOV trips

<u>Multimodal Opportunities – Bicycle Accommodation</u>

Cyclists may choose to utilize state highways or interstates (unless specifically prohibited) as a mode of travel. Thus, bicycle consideration is considered an important element of the Multimodal Opportunities provided by a corridor, particularly for non-interstate facilities. Using guidance from AASHTO, effective right-shoulder widths were defined based on shoulder characteristics as a function of the facility's posted speed limit and AADT. The corridor's shoulders are compared to the following criteria:

- If AADT ≤ 1500 VPD or Speed Limit < 25 MPH: The segment's general purpose lane can be shared with Bicyclists
- If AADT > 1500 and Speed Limit is between 25 – 50 MPH and Pavement Surface is Paved: Effective shoulder width required is 4 feet or greater
- If AADT > 1500 and Speed Limit ≥ 50 MPH and Pavement Surface is Paved: Effective shoulder width required is 6 feet or greater

The summation of the length of the shoulder sections that meet the defined effective width criteria, based on criteria above, will be divided by the segments total length to estimate the percent of the segment that accommodates bicycle use. The performance thresholds are as followed:

- Good: > 90%
- Fair: 60% - 90%
- Poor: < 60%

3.3.3 I-10/SR 85 Mobility Performance

The Mobility Index and secondary performance measures were calculated for the I-10/SR 85 corridor as described in the previous sections. The calculations were based on data provided by ADOT from the HPMS system for the year 2014, the AZTDM for the years 2010 and 2035, HERE data from 2014, and closure data from 2010 to 2014. The Mobility Index provides a top-level assessment of the traffic operational condition for the corridor and for each segment. The Future V/C, Peak Hour V/C, Closure, TTI, and PTI measures provide more detailed information to assess the traffic operational conditions for each segment. The resulting scores are shown in **Table 5**.

The results for the Mobility Index and secondary measures are shown in **Figure 15** through **Figure 22**.

Based on the results of this analysis, the following observations could be made:

- Overall, based on the weighted average of the Mobility Index, the traffic operations are in “good” condition
- The existing peak hour traffic operations are “good”
- The future traffic operations are anticipated to perform “poor” in two of the fourteen segments
- Segments 12 and 14 have the lowest Mobility Index and perform the worst in the Future V/C performance measure
- Half of the segments show “fair” performance in the Closure performance measure
- Segment 9 has the highest number of closures
- The TTI measures generally show “good” along the corridor, except for four segments, where two show “fair”, and two show “poor”
- Half of the segments in the PTI measures show “poor” condition
- A majority of the corridor shows “poor” or “fair” performance for non-SOV trips meaning that many vehicles carry only a single occupant
- The majority of the segments show a “good” performance for accommodation of bicycles, however three segments show a “poor” performance, and two segments show “fair”
- Bicycles are not prohibited on any segment of the I-10/SR 85 corridor. Segments 85-12, 85-13, and 85-14 have the lowest percentage of bicycle accommodations along the corridor.

Table 5: Mobility Performance Summary

Segment	Segment Length (miles)	Mobility Performance Area											
		Mobility Index	Future Daily V/C	Existing Peak Hour V/C		Closure Extent (occurrences /year/mile)		Directional TTI (all vehicles)		Directional PTI (all vehicles)		% Bicycle Acc.	% Non-SOV Trips
				NB/WB	EB/SB	NB/WB	EB/SB	NB/WB	EB/SB	NB/WB	EB/SB		
10W-1	16	0.27	0.30	0.28	0.28	0.30	0.05	1.20	1.17	1.57	1.54	100%	11.9%
10W-2	6	0.30	0.32	0.29	0.29	0.23	0.03	1.13	1.10	1.30	1.25	100%	15.2%
10W-3	10	0.27	0.29	0.28	0.28	0.08	0.18	1.15	1.10	1.34	1.24	99%	19.7%
10W-4	22	0.31	0.34	0.34	0.34	0.14	0.11	1.11	1.09	1.24	1.23	100%	10.7%
10W-5	17	0.29	0.32	0.29	0.29	0.13	0.28	1.11	1.08	1.27	1.20	100%	5.3%
10W-6	11	0.29	0.32	0.31	0.27	0.24	0.36	1.10	1.09	1.21	1.23	100%	6.1%
10W-7	16	0.32	0.36	0.34	0.29	0.40	0.11	1.10	1.10	1.24	1.23	100%	12.5%
10W-8	15	0.53	0.70	0.35	0.34	0.12	0.11	1.11	1.10	1.25	1.25	100%	14.6%
85-9	6	0.30	0.39	0.18	0.18	0.07	0.77	1.00	1.05	1.32	1.76	88%	19.3%
85-10	11	0.23	0.28	0.16	0.15	0.25	0.00	1.07	1.00	1.83	1.07	100%	13.6%
85-11	15	0.17	0.20	0.09	0.09	0.13	0.03	1.01	1.09	1.16	1.84	94%	8.2%
85-12	3	0.92	1.11	0.56	0.56	0.27	0.07	1.00	1.19	1.00	3.19	32%	8.8%
85-13	2	0.32	0.35	0.25	0.25	No Data Available		1.85	1.47	NO DATA	4.26	47%	9.0%
85-14	3	1.01	1.24	0.67	0.66	No Data Available		1.28	1.89	9.05	4.25	42%	7.0%
Weighted Average		0.33											

Urban (Rural)

	Uninterrupted Flow					
Good	< 0.71 (< 0.56)	< 0.22	< 1.15	< 1.30	> 90%	> 17%
Fair	0.71 – 0.89 (0.56 – 0.76)	0.22 – 0.62	1.15 – 1.33	1.30 – 1.50	60% - 90%	11% - 17%
Poor	> 0.89 (> 0.76)	> 0.62	> 1.33	> 1.50	< 60%	< 11%

Interrupted Flow	
<1.30	<3.00
1.30-2.00	3.00-6.00
>2.00	>6.00

Figure 15: Mobility Index

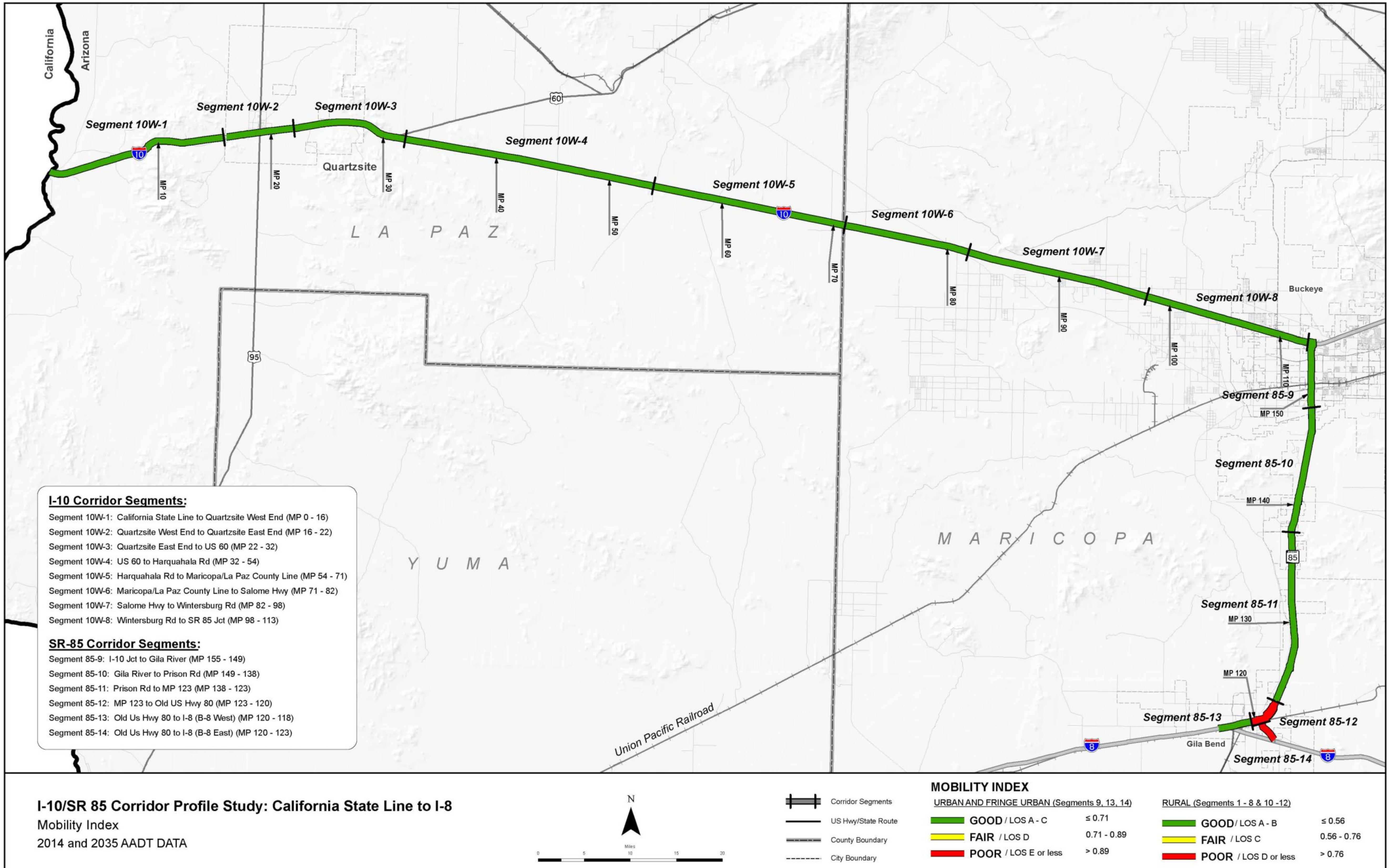


Figure 16: Future V/C

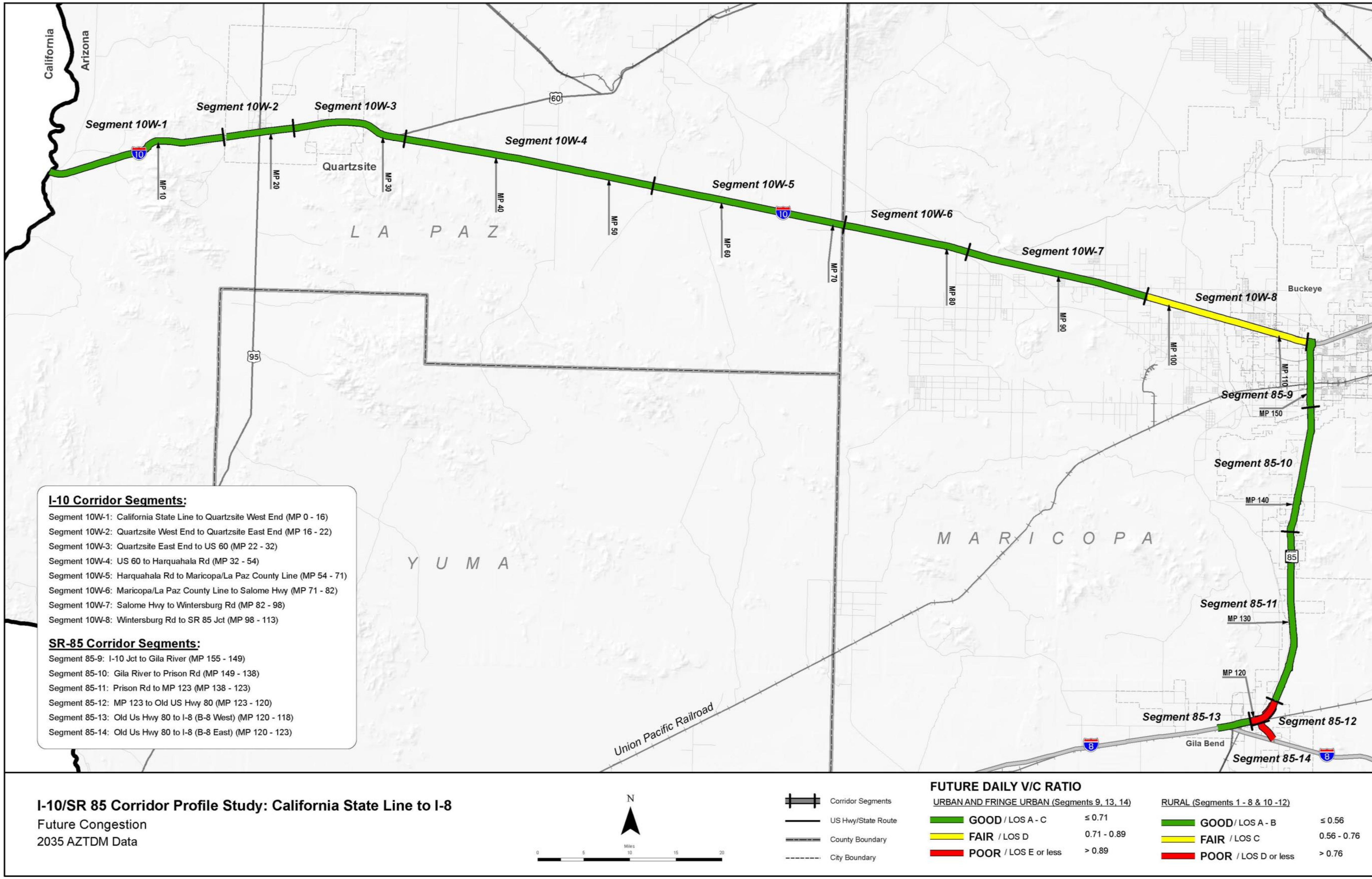


Figure 17: Existing Peak Hour V/C

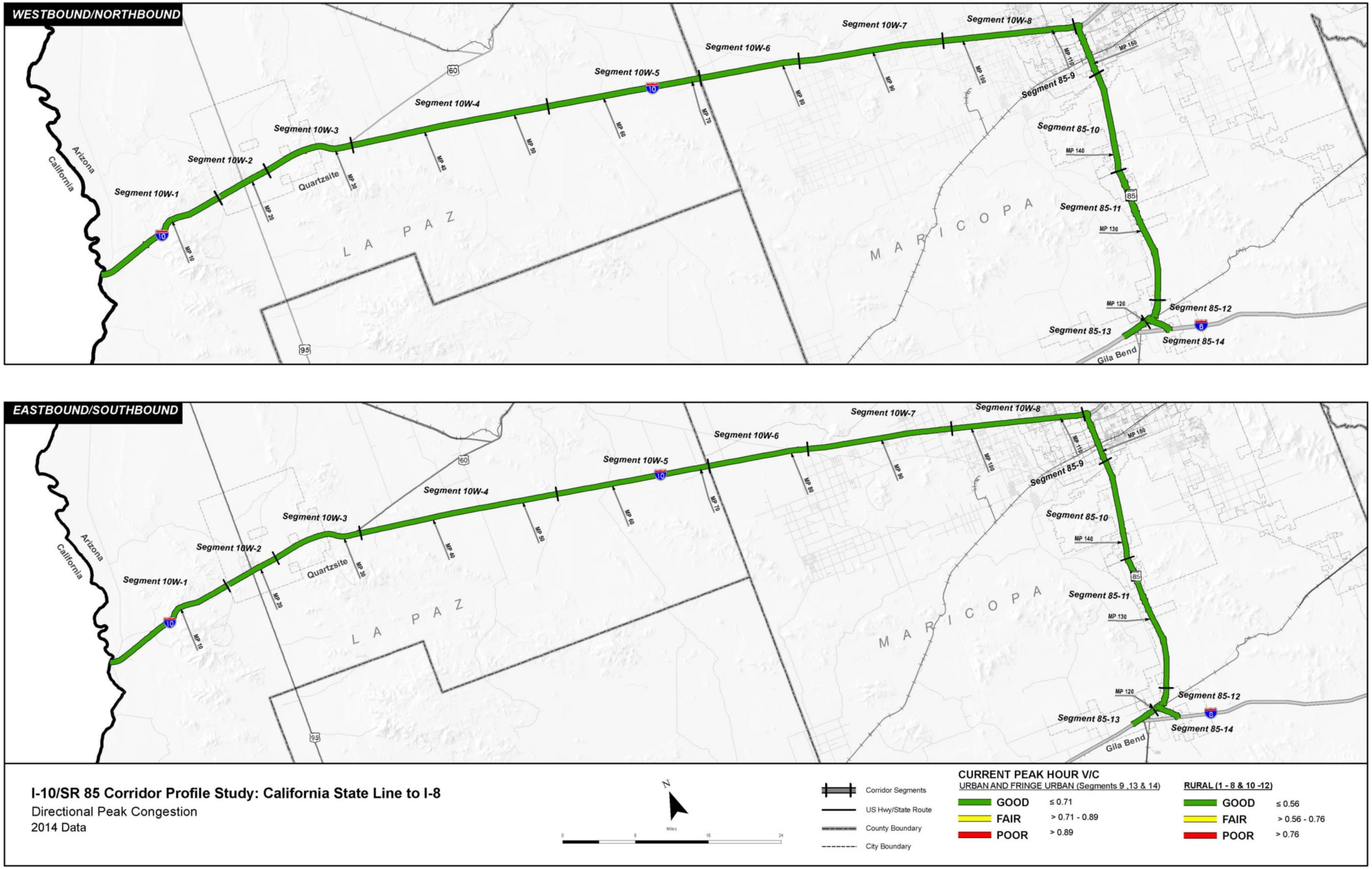


Figure 18: Road Closure Frequency

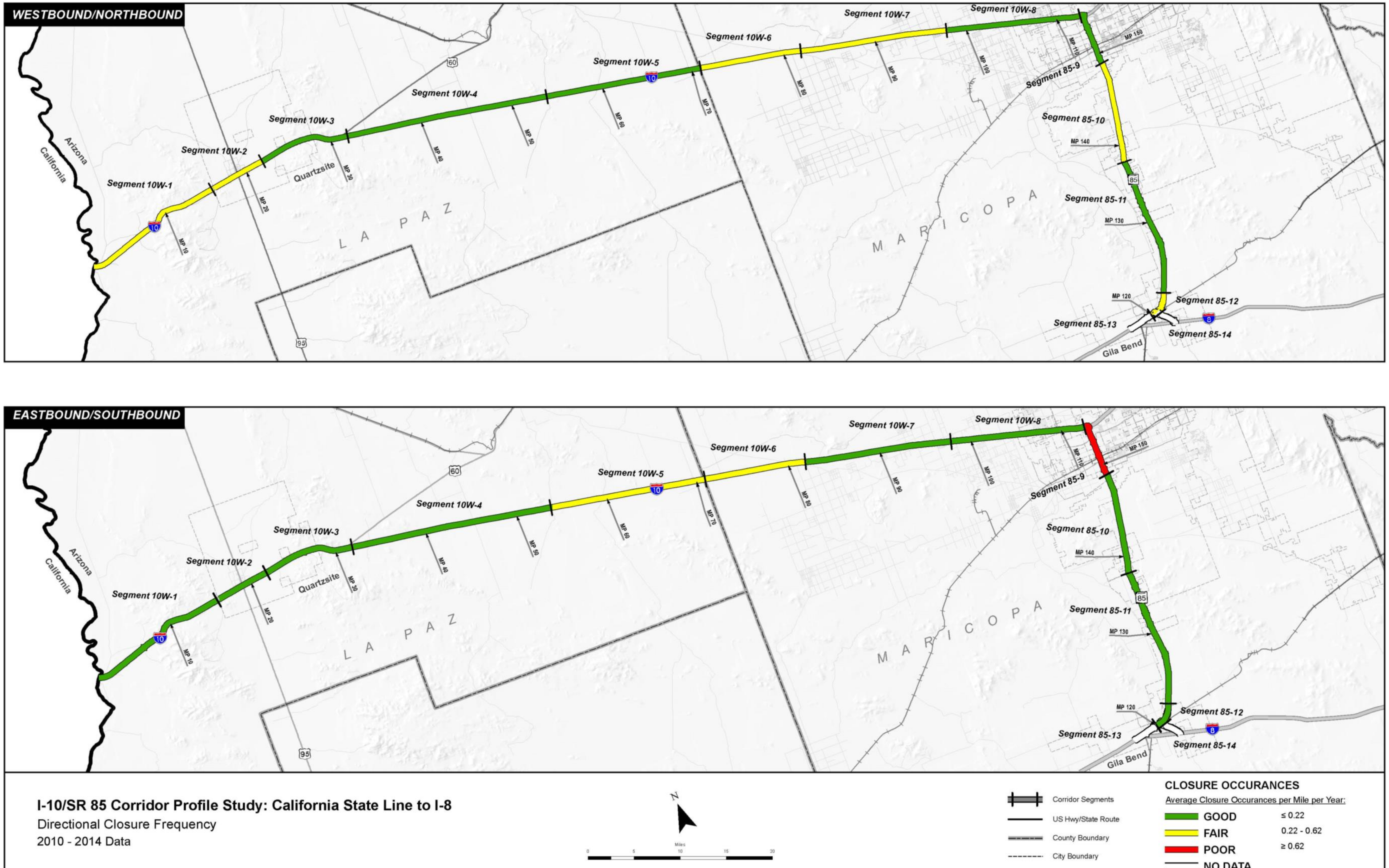


Figure 19: Travel Time Index

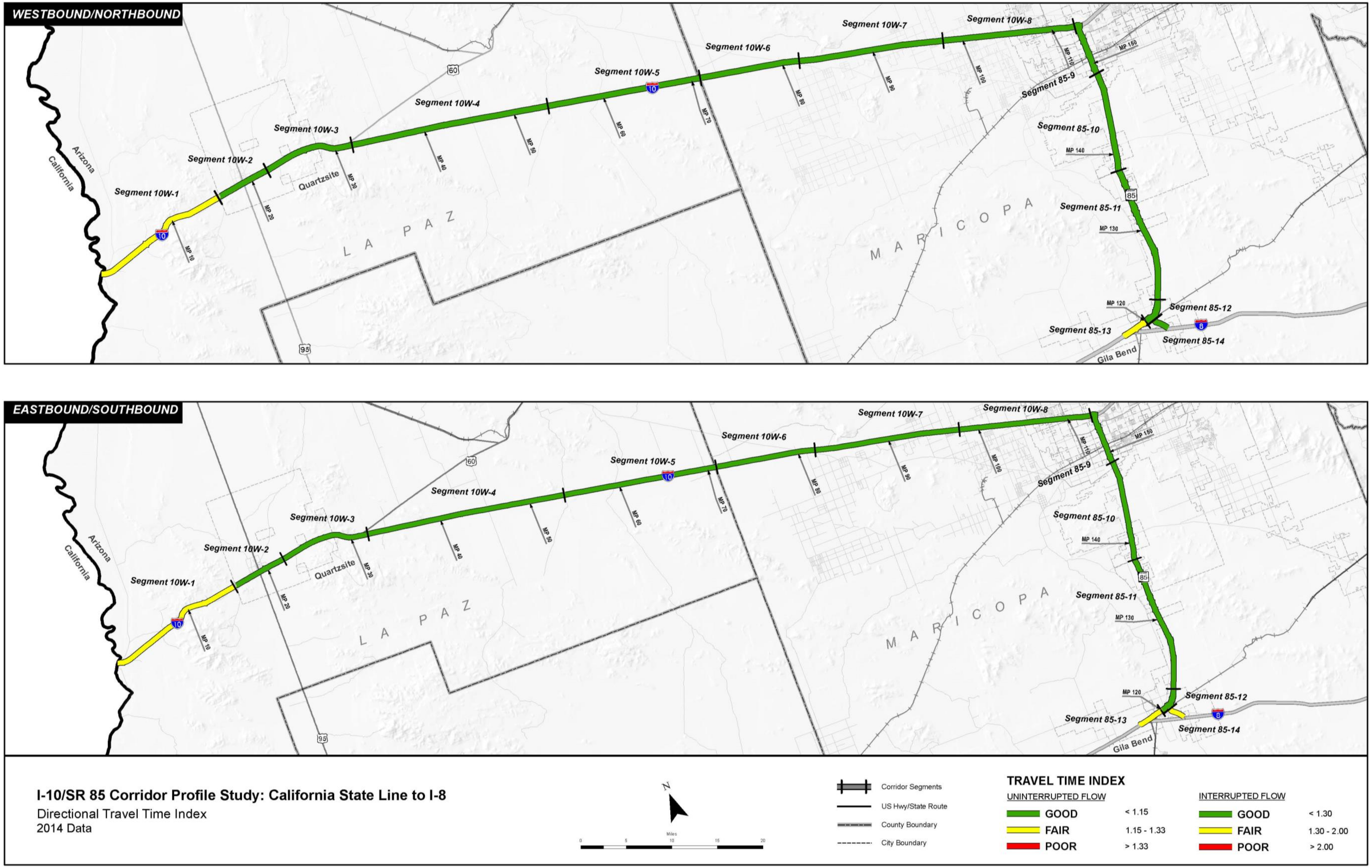


Figure 20: Planning Time Index

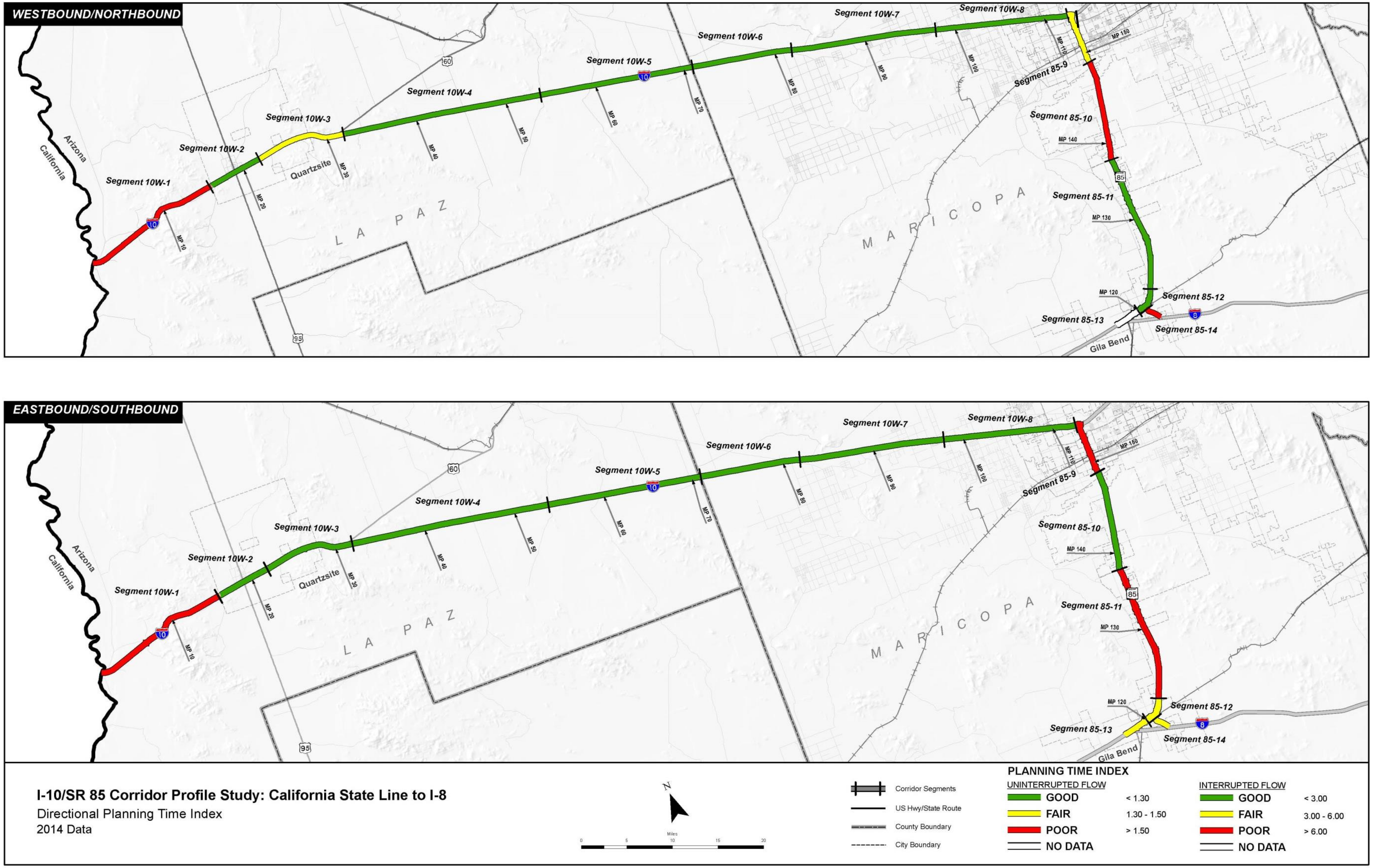


Figure 21:Multimodal Opportunities

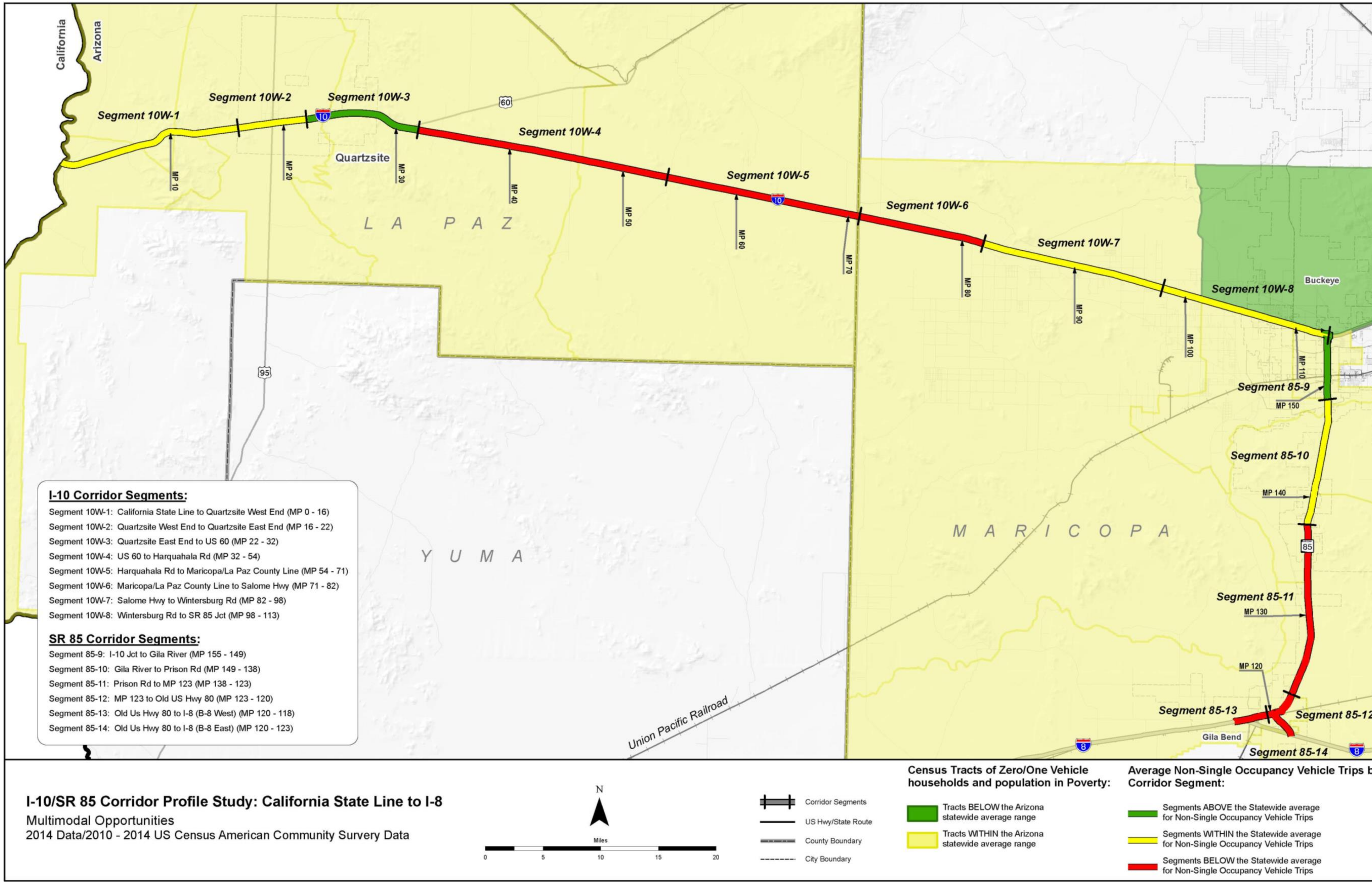
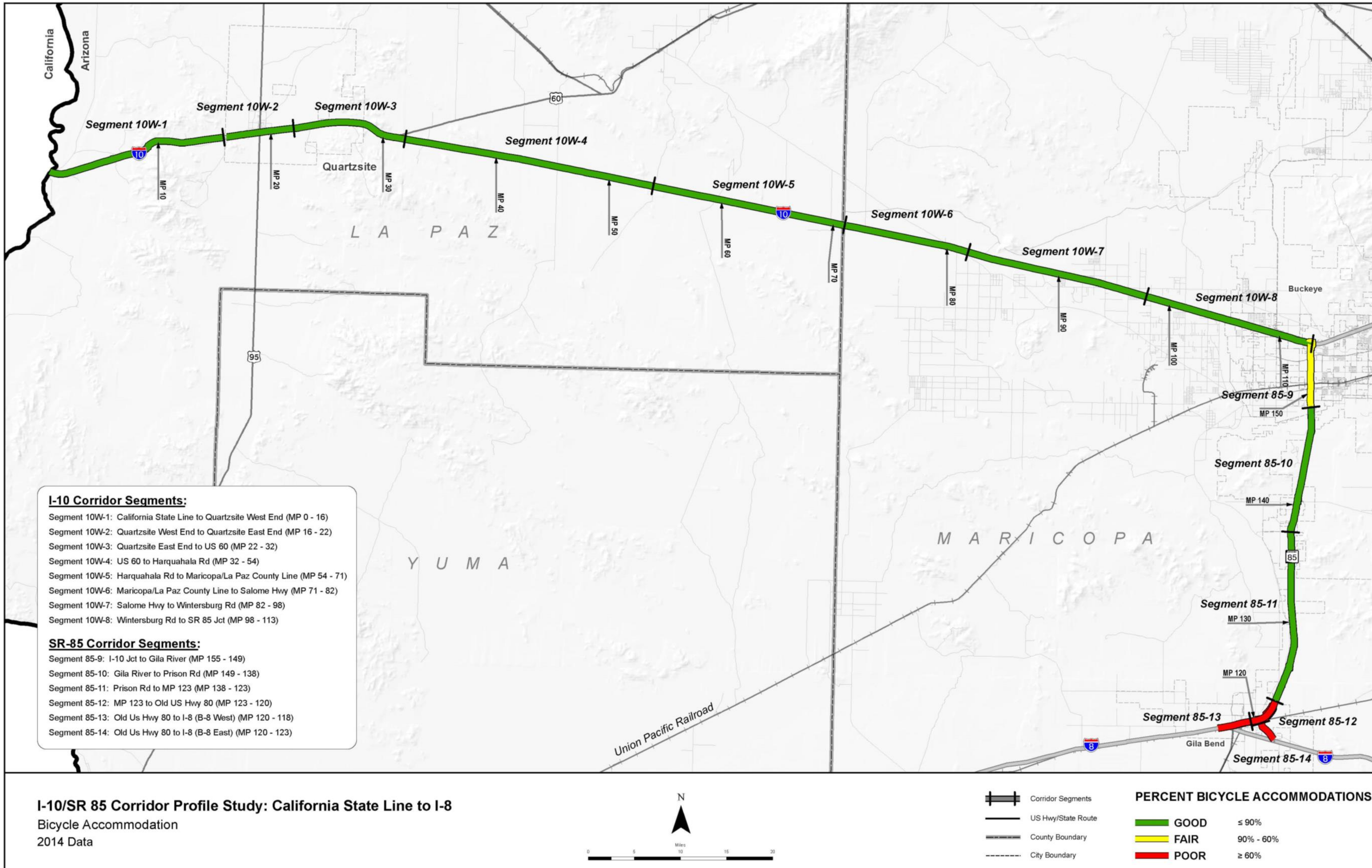


Figure 22: Bicycle Accommodation



3.4. Safety Performance Area

The safety performance area consists of a single Safety Index and four secondary measures as illustrated in **Figure 23**. All measures relate to crashes that result in fatal and incapacitating injuries, as these crash types are the emphasis of ADOT and MAP-21. The Safety Performance Area was developed in collaboration with ADOT Safety Group. Detailed information related to the calculations for the Safety Performance Area is included in Appendix B of this Working Paper.

Figure 23: Safety Performance Area

3.4.1 Primary Measure

The Safety Index is a safety performance measure based on the bi-directional (i.e., both directions combined) frequency and rate of fatal and incapacitating injury crashes, the relative cost of those types of crashes, and crash occurrences on similar roadways in Arizona. According to ADOT's 2010 Highway Safety Improvement Program Manual, fatal crashes have an estimated cost that is 14.5 times the estimated cost of incapacitating injury crashes ($5.8 million compared to $400,000).

The Combined Safety Score (CSS) is an interim measure that combines fatal and serious injury crashes into a single value. The CSS is calculated using the following generalized formula:

*CSS = 14.5 * (Normalized Fatal Crash Rate + Frequency) + (Normalized Incapacitating Injury Crash Rate + Frequency)*

Because crashes vary depending on the operating environment of a particular roadway, statewide CSS values were developed for similar operating environments defined by functional classification, urban vs. rural setting, number of travel lanes, and traffic volumes. To determine the Safety Index of a particular I-10/SR 85 segment, the segment CSS was compared to the average statewide CSS for the similar statewide operating environment. For I-10/SR 85, five operating environments were identified:

- Rural 4-Lane Freeway with Daily Volume < 25,000
- Rural 4-Lane Freeway with Daily Volume > 25,000
- 2 or 3 or 4 Lane Divided Highway
- 2 or 3 Lane Undivided Highway
- 4 or 5 Lane Undivided Highway

The Safety Index is calculated using the following formula:

Safety Index = Segment CSS / Statewide Similar Operating Environment CSS

The average annual Safety Index for a segment is compared to the statewide similar operating environment annual average, with one standard deviation from the statewide average forming the scale break points.

The more a particular segment's Safety Index value is below the statewide similar operating environment average, the better the safety performance is for that particular segment as a lower value represents fewer crashes.

The scale for rating the Safety Index depends on the operating environments selected for a particular corridor. For I-10/SR 85 the scales for rating the Safety Index are:

Rural 4-Lane Freeway with Daily Volume < 25,000
- Above average performance: < 0.73
- Average performance: 0.73 - 1.27
- Below average performance: > 1.27

Rural 4-Lane Freeway with Daily Volume >25,000
- Above average performance: < 0.68
- Average performance: 0.68 - 1.32
- Below average performance: > 1.32

2 or 3 or 4 Lane Divided Highway
- Above average performance: < 0.77
- Average performance: 0.77 - 1.23
- Below average performance: > 1.23

2 or 3 Lane Undivided Highway
- Above average performance: < 0.94
- Average performance: 0.94 - 1.06
- Below average performance: > 1.06

4 or 5 Lane Undivided Highway
- Above average performance: < 0.80
- Average performance: 0.80 - 1.20
- Below average performance: > 1.20

3.4.2 Secondary Measures

The Safety Performance Area has four secondary measures related to fatal and incapacitating injury crashes:

- Directional Safety Index
- *Strategic Highway Safety Plan* (SHSP) Behavior Emphasis Areas
- SHSP Crash Unit Type Emphasis Areas
- Safety Hot Spots

The SHSP behavior emphasis areas and SHSP crash unit type emphasis areas secondary safety performance measures for the Safety Performance Area include proportions of specific types of crashes within the total fatal and incapacitating injury crash frequencies. This more detailed categorization of fatal and incapacitating injury crashes can result in low crash frequencies (i.e., a small sample size) that translate into performance ratings that can be unstable. In some cases, a change in crash frequency of one crash (one additional crash or one less crash) could result in a change in segment performance of two levels. To avoid reliance on performance ratings where small changes in crash frequency result in large changes in performance, the following criteria were developed to identify segments with "insufficient data" for assessing performance for the two SHSP-related secondary safety performance measures:

- If the crash sample size (total fatal plus serious injury crashes) for a given segment is less than five crashes over the five-year analysis period, the segment has "insufficient data" and performance ratings are unreliable.
- If a change in one crash results in a change in segment performance by two levels (i.e., a change from below average to above average performance or a change from above average to below average frequency), the segment has "insufficient data" and performance ratings are unreliable.
- If the corridor average segment crash frequency for a specific SHSP-related secondary safety performance measure type is less than two crashes over the five-year analysis period, the entire SHSP-related secondary performance measure has "insufficient data" and performance ratings are unreliable.

<u>Directional Safety Index</u>

The Direction Safety Index shares the same calculation procedure and thresholds as the Safety Index. However, the measure is based on the directional frequency and rate of fatal and incapacitating injury crashes.

Similar to the Safety Index, the segment CSS was compared to the average statewide CSS for the similar statewide operating environment.

<u>SHSP Behavior Emphasis Areas</u>

ADOT's 2014 SHSP identifies several emphasis areas for reducing fatal and incapacitating injury crashes. The top five SHSP emphasis areas relate to the following driver behaviors:

- Speeding and aggressive driving
- Impaired driving
- Lack of restraint usage
- Lack of motorcycle helmet usage
- Distracted driving

To develop a performance measure that reflects these five emphasis areas, the percentage of total fatal and incapacitating injury crashes that involves at least one of the emphasis area driver behaviors on a particular segment is compared to the statewide average percentage of crashes involving at least one of the emphasis area driver behaviors on roads with similar operating environments in a process similar to how the Safety Index is developed.

To increase the crash sample size for this performance measure, the five behavior emphasis areas are combined to identify fatal and incapacitating injury crashes that exhibit one or more of the behavior emphasis areas.

The SHSP behavior emphasis areas performance is calculated using the following formula:

% Crashes Involving SHSP Behavior Emphasis Areas = Segment Crashes Involving SHSP Behavior Emphasis Areas / Total Segment Crashes

The percentage of total crashes involving SHSP behavior emphasis areas for a segment is compared to the statewide percentages on roads with similar operating environments. One standard deviation from the statewide average percentage forms the scale break points.

When assessing the performance of the SHSP behavior emphasis areas, the more the frequency of crashes involving SHSP behavior emphasis areas is below the statewide average implies better levels of segment performance. Thus, lower values are better, similar to the Safety Index.

The scale for rating the SHSP behavior emphasis areas performance depends on the crash history on similar statewide operating environments. In the case of the I-10/SR 85 corridor, the scales for rating the SHSP behavior emphasis areas performance are:

Rural 4-Lane Freeway with Daily Volume < 25,000
- Above average performance: < 0.43
- Average performance: 0.43-0.53
- Below average performance: > 0.53

2 or 3 Lane Undivided Highway
- Above average performance: < 0.51
- Average performance: 0.51 – 0.58
- Below average performance: > 0.58

Rural 4-Lane Freeway with Daily Volume >25,000
- Above average performance: < 0.41
- Average performance: 0.41 – 0.57
- Below average performance: > 0.57

4 or 5 Lane Undivided Highway
- Above average performance: < 0.42
- Average performance: 0.42 – 0.51
- Below average performance: > 0.51

2 or 3 or 4 Lane Divided Highway
- Above average performance: < 0.44
- Average performance: 0.44 – 0.54
- Below average performance: > 0.54

SHSP Crash Unit Type Emphasis Areas
ADOT's SHSP also identifies emphasis areas that relate to the following "unit-involved" crashes:

- Heavy vehicle (trucks)-involved crashes
- Motorcycle-involved crashes
- Non-motorized traveler (pedestrians and bicyclists)-involved crashes

To develop a performance measure that reflects the aforementioned crash unit type emphasis areas, the percentage of total fatal and incapacitating injury crashes that involves a given crash unit type emphasis area on a particular segment is compared to the statewide average percentage of crashes involving that same crash unit type emphasis area on roads with similar operating environments in a process similar to how the Safety Index is developed.

The SHSP crash unit type emphasis areas performance is calculated using the following formula:

% Crashes Involving SHSP Crash Unit Type Emphasis Areas = Segment Crashes Involving SHSP Crash Unit Type Emphasis Areas / Total Segment Crashes

The percentage of total crashes involving SHSP crash unit type emphasis areas for a segment is compared to the statewide percentages on roads with similar operating environments. One standard deviation from the statewide average percentage forms the scale break points.

When assessing the performance of the SHSP crash unit type emphasis areas, the more the frequency of crashes involving SHSP crash unit type emphasis areas is below the statewide average implies better levels of segment performance. Thus, lower values are better, similar to the Safety Index.

Safety Hot Spots
A "hot spot" analysis was conducted that identified abnormally high concentrations of fatal and incapacitating injury crashes along the study corridor by direction of travel. The identification of crash concentrations involves a geographic information system (GIS)-based function known as "kernel density analysis". This measure is mapped for graphical display purposes but is not included in the Safety Performance Area rating calculations.

3.4.3 I-10/SR 85 Safety Performance

The Safety Index and secondary performance measures were calculated for the I-10/SR 85 corridor as described in the previous section. The safety measures were calculated using data provided by ADOT for the timeframe from January 2010 to December 2014. The Safety Index provides a top-level assessment of the safety performance for the corridor and for each segment. The three supplemental measures provide more detailed information to assess the safety performance for each segment. The resulting scores are shown in **Table 6**. As discussed in the previous section, all analysis is based on fatal and incapacitating injury crashes.

The scale for rating the SHSP crash unit type emphasis areas performance depends on the crash history on similar statewide operating environments. For I-10/SR 85, it was determined that the SHSP crash unit type performance measures for crashes involving heavy vehicle (trucks) for half of the segments, and motorcycles and non-motorized travelers for all segments have insufficient data (i.e., too small of a sample size) to generate reliable performance ratings so these secondary safety performance measures were removed from the performance evaluation.

The results for the Safety Index and secondary measures are shown in **Figure 24**, **Figure 25**, and **Figure 26**.

Based on the results of this analysis, the following observations could be made:

- Overall, based on the weighted average of the Safety Index, the corridor rates in "below average performance" condition
- The segments are about divided evenly among the three rating performances, where 5 segments are "above average performance", 4 are "average performance", and 5 are "below average performance"
- Segment 4 performs below average in the Safety Index, top 5 SHSP emphasis areas, and both directions of travel for the directional safety index.
- There are several locations of high crash frequency, including eastbound/southbound in Segments 4, 5, 6, 7, 8 and 9, and northbound/westbound in Segments 2, 4, 7 and 9.

Table 6: Safety Performance Summary

Segment	Segment Length (miles)	Safety Performance Area: Safety Index	Directional Safety Index: EB/SB	Directional Safety Index: NB/WB	% of Fatal + Incapacitating Injury Crashes Involving SHSP Top 5 Emphasis Areas Behaviors	% of Fatal + Incapacitating Injury Crashes Involving Trucks
10W-1	16	0.76	0.43	1.10	58%	8%
10W-2	6	0.99	0.12	1.86	40%	Insufficient Data
10W-3	10	1.03	1.20	0.87	54%	15%
10W-4	22	1.79	1.92	1.65	54%	11%
10W-5	17	1.60	2.08	1.12	35%	35%
10W-6	11	1.66	2.62	0.70	56%	17%
10W-7	16	2.60	1.48	3.72	40%	20%
10W-8	15	1.05	1.39	0.71	50%	19%
85-9	6	3.12	3.20	3.05	Insufficient Data	Insufficient Data
85-10	11	0.54	1.08	0.00	Insufficient Data	Insufficient Data
85-11	15	0.26	0.50	0.03	Insufficient Data	Insufficient Data
85-12	3	0.11	0.00	0.23	Insufficient Data	Insufficient Data
85-13	2	0.17	0.00	0.35	Insufficient Data	Insufficient Data
85-14	3	0.00	0.00	0.00	Insufficient Data	Insufficient Data
Weighted Average		1.31				

Safety Performance Summary Thresholds

	Safety Index & Directional Safety	% of Fatal + Incapacitating Injury Crashes Involving SHSP Top 5 Emphasis Areas Behaviors	% of Fatal + Incapacitating Injury Crashes Involving Trucks
Rural 4-Lane Freeway With Daily Volume < 25,000			
Above Average Performance	< 0.73	< 43%	<13.2%
Average Performance	0.73 – 1.27	43% - 53%	13.2%-17.0%
Below Average Performance	> 1.27	> 53%	>17.0%
Rural 4-Lane Freeway With Daily Volume > 25,000			
Above Average Performance	< 0.68	< 40.8%	<7.2%
Average Performance	0.68-1.32	43% - 57.1%	7.2%-12.9%
Below Average Performance	> 1.32	> 57.1%	>12.9%
2 or 3 or 4 Lane Divided Highway			
Above Average Performance	< 0.77	< 44%	<3.5%
Average Performance	0.77-1.23	44-54.4%	3.5%-7.3%
Below Average Performance	> 1.23	> 54.4%	>7.3%
2 or 3 Lane Undivided Highway			
Above Average Performance	< 0.94	< 51.2%	<5.2%
Average Performance	0.94 – 1.06	51.2% - 57.5%	5.2%-7.1%
Below Average Performance	> 1.06	> 57.5%	>7.1%
4 or 5 Lane Undivided Highway			
Above Average Performance	< 0.80	< 42.4%	<6.1%
Average Performance	0.80-1.20	42.4-51.1%	6.1%-9.6%
Below Average Performance	> 1.20	> 51.1%	>9.6%

Figure 24: Safety Index

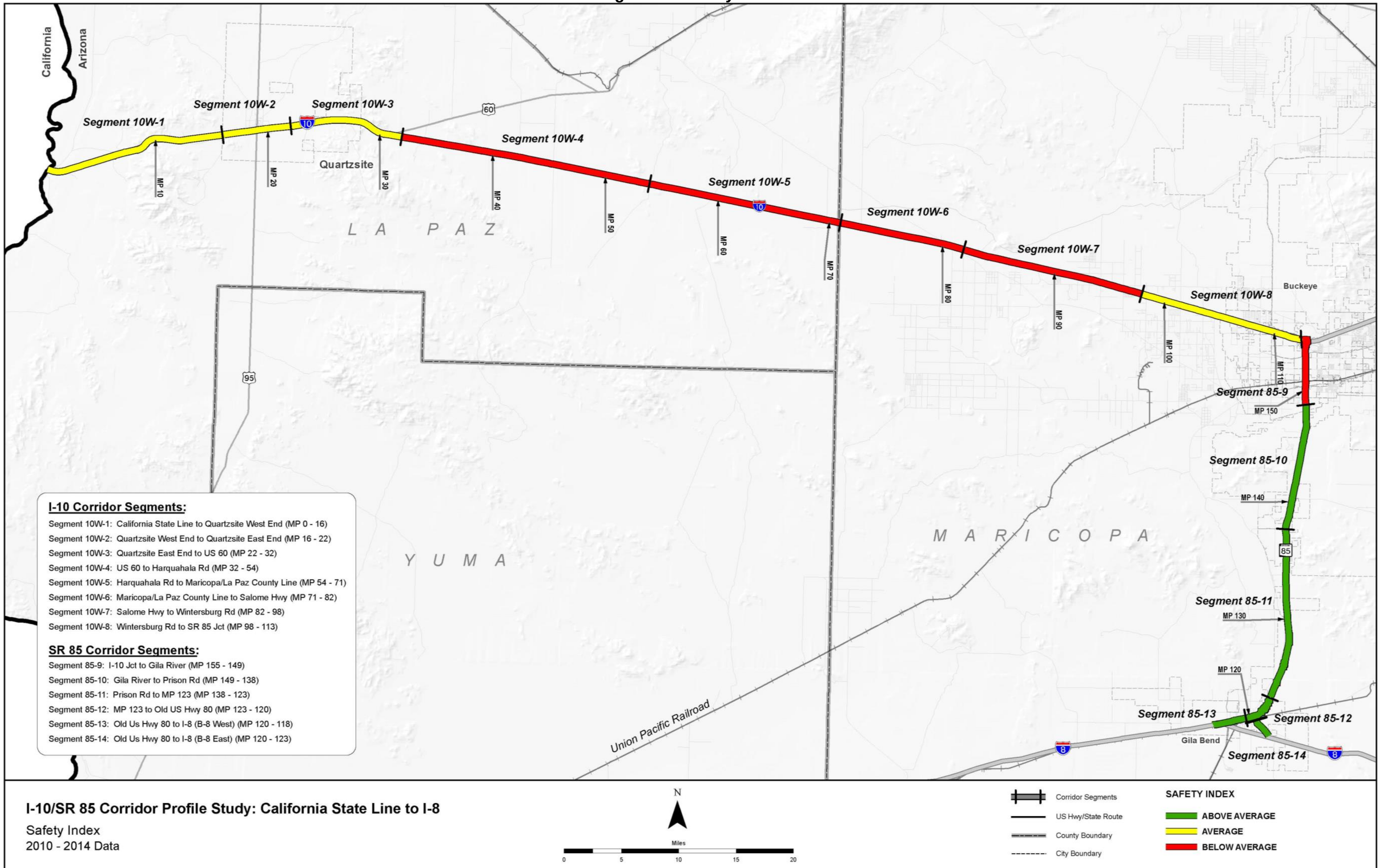


Figure 25: Directional Safety Index

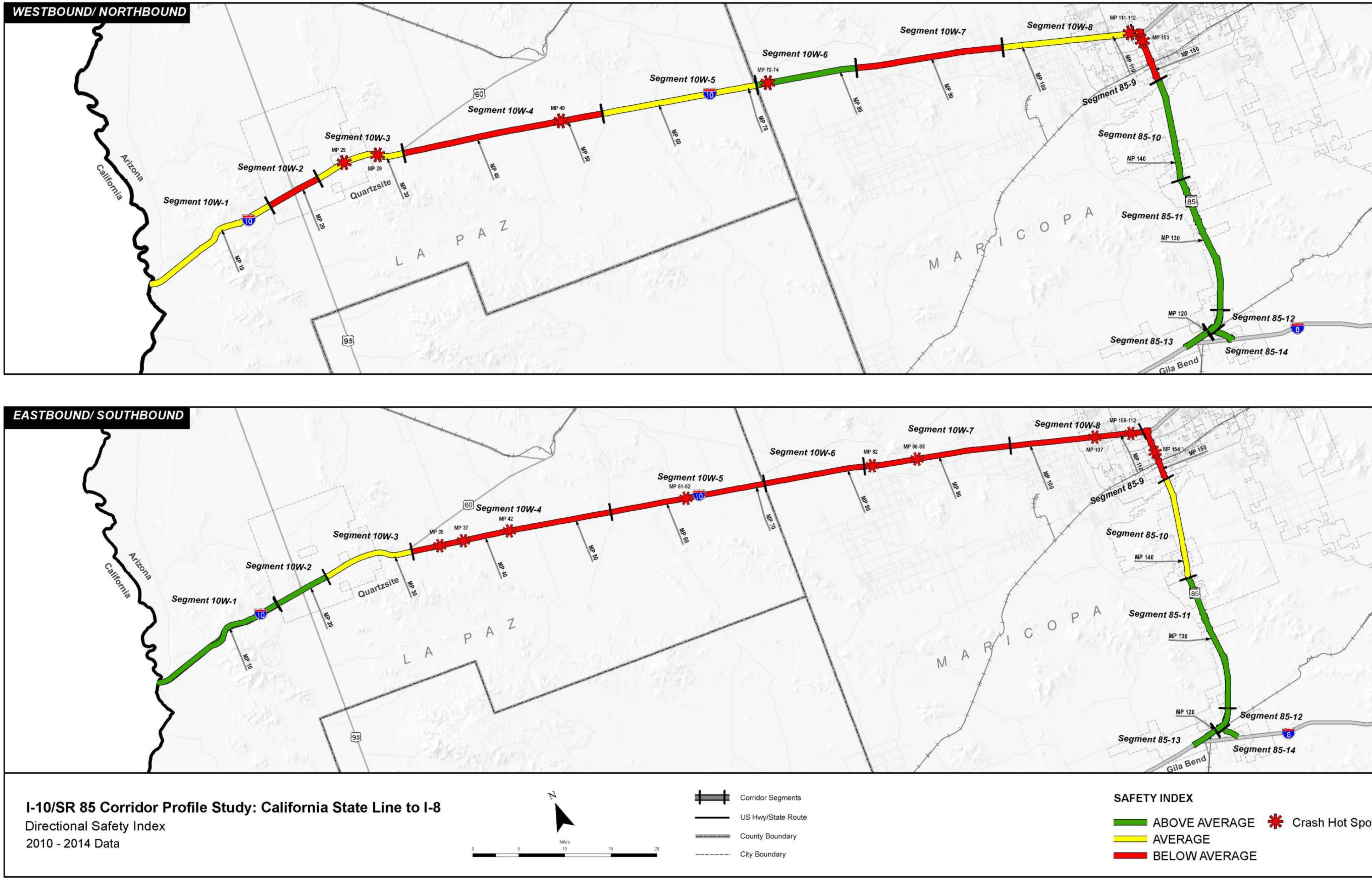


Figure 26-1: Frequency of SHSP Top 5 Emphasis Areas

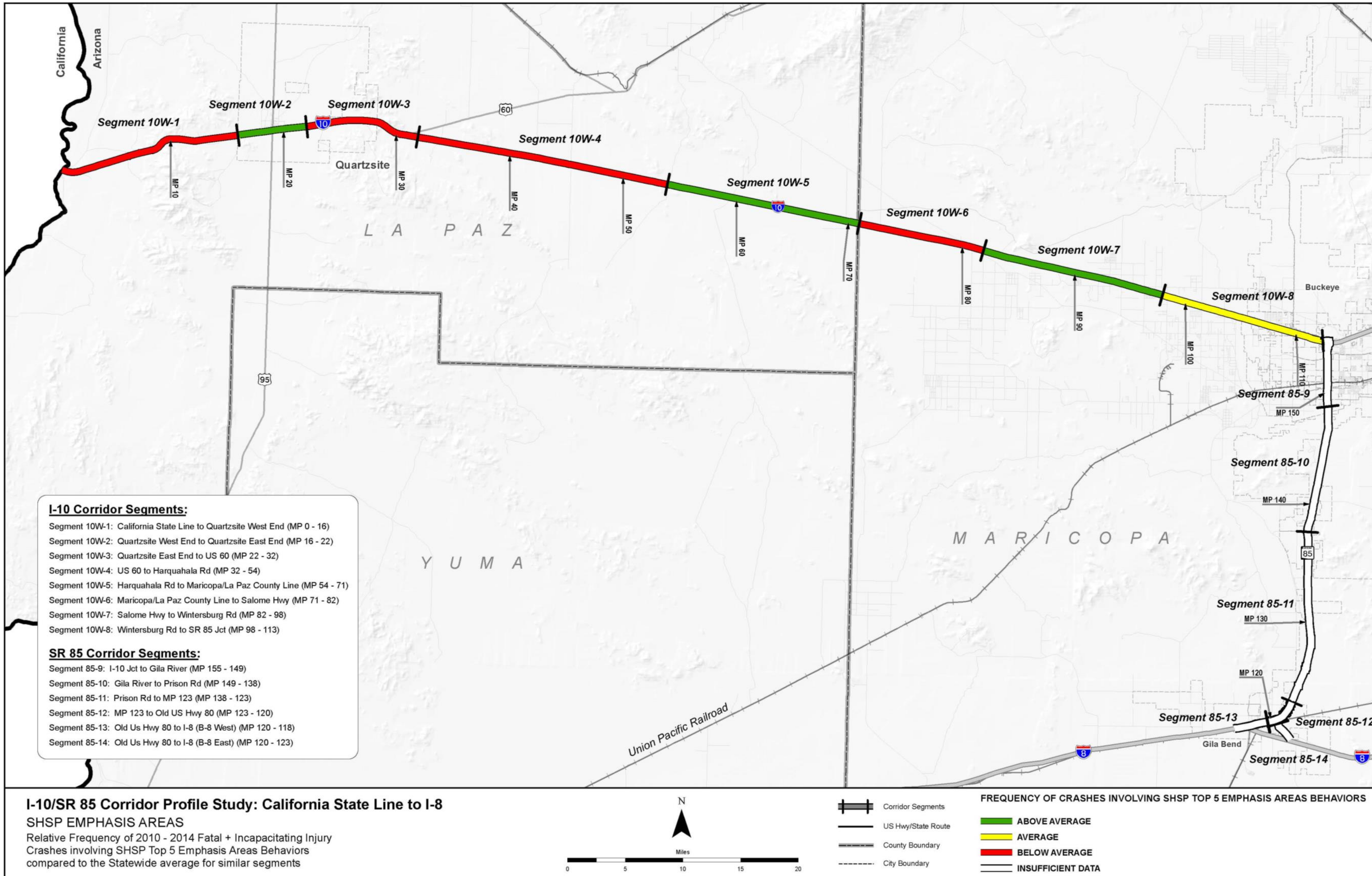
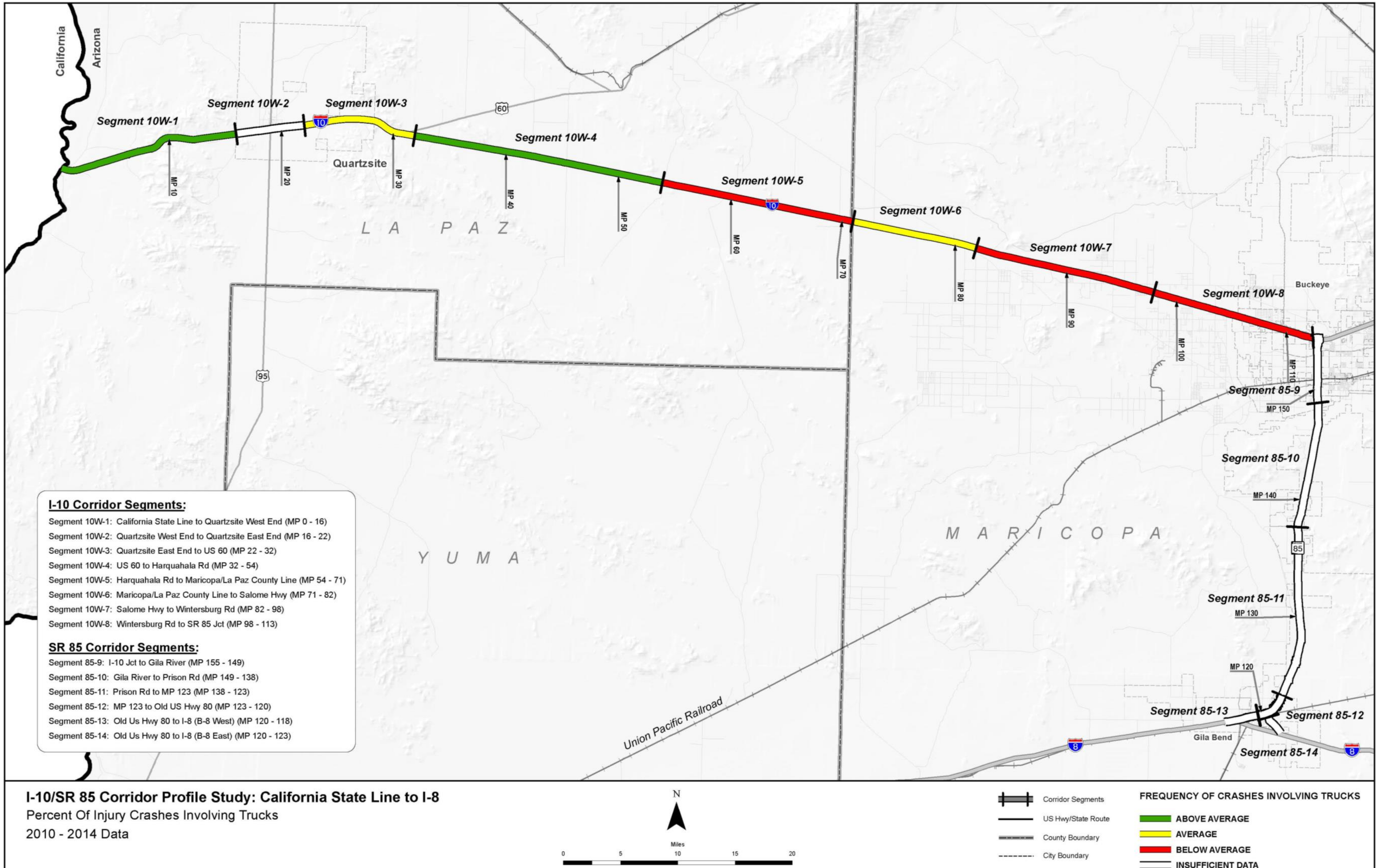


Figure 26-2: Percent of Injury Crashes Involving Trucks



3.5. Freight Performance Area

The freight performance area consists of a single Freight Index and five secondary measures as illustrated in **Figure 27**. All measures relate to the reliability of truck travel as measured by observed truck travel time speed and delays to truck travel from freeway closures or physical restrictions to truck travel. The Freight Performance Area was developed in collaboration with ADOT's Freight Planner. Detailed information related to the calculations for the Freight Performance Area is included in Appendix B of this Working Paper.

Figure 27: Freight Performance Area Measures

3.5.1 Primary Measure

The Freight Index is a reliability performance measure based on the planning time index for truck travel. The industry standard definition for the Truck Planning Time Index (TPTI) is the ratio of total travel time needed for 95% on-time arrival to free-flow travel time. The TPTI reflects the extra buffer time needed for on-time delivery while accounting for non-recurring delay. Non-recurring delay refers to unexpected or abnormal delay due to closures or restrictions resulting from circumstances such as crashes, inclement weather, and construction activities.

The TPTI can be converted into a speed-based index by recognizing that speed is equal to distance traveled divided by travel time. The inverse relationship between travel time and speed means that the 95th percentile highest travel time corresponds to the 5th percentile lowest speed. The speed-based TPTI is calculated using the following formula:

TPTI = Free-Flow Truck Speed / Observed 5th Percentile Lowest Truck Speed

Observed 5th percentile lowest truck speeds are available in the 2014 American Digital Cartography, Inc. HERE (formerly NAVTEQ) database to which ADOT has access. The free-flow truck speed is assumed to be 65 miles per hour (mph) or the posted speed, whichever is less. This upper limit of 65 mph accounts for governors that trucks often have that restrict truck speeds to no more than 65 mph, even when the speed limit may be higher.

For each corridor segment, the TPTI is calculated for each direction of travel and then averaged to create a bi-directional TPTI. When assessing performance using TPTI, the higher the TPTI value is above 1.0, the more buffer time is needed to ensure on-time delivery.

The Freight Index can be calculated using the following formula to invert the overall TPTI:

Freight Index = 1 / Bi-directional TPTI

This inversion of the TPTI allows the Freight Index to have a scale where the higher the value, the better the performance, which is similar to the directionality of the scales of the other Primary Measures. This Freight Index scale is based on inverted versions of TPTI scales created previously by ADOT.

The scale for rating the Freight Index is:

Uninterrupted Flow Facilities

- Good: > 0.77
- Fair: 0.67 - 0.77
- Poor: < 0.67

Interrupted Flow Facilities

- Good: > 0.33
- Fair: 0.17-0.33
- Poor: < 0.17

3.5.2 Secondary Measures

The Freight Performance Area has five secondary measures:

- Non-Recurring Delay (Directional TPTI)
- Recurring Delay (Directional TTTI)

- Road Closures (Directional Closure Duration)
- Bridge Vertical Clearance
- Truck Restriction Hot Spots (Vertical Clearance)

Non-Recurring Delay (Directional TPTI)

The performance measure for non-recurring delay is the Directional TPTI. Directional TPTI is calculated as described previously as an interim step in the development of the Freight Index.

For each corridor segment, the TPTI is calculated for each direction of travel. With the TPTI, the higher the TPTI value is above 1.0, the more buffer time is needed to ensure on-time delivery.

The scale for rating the Directional TPTI is the inverse of the Freight Index:

Uninterrupted Flow Facilities

- Good: < 1.30
- Fair: 1.30 – 1.50
- Poor: > 1.50

Interrupted Flow Facilities

- Good: < 1.30
- Fair: 1.30 – 2.00
- Poor: > 2.00

Recurring Delay (Directional TTTI)

The performance measure for recurring delay is the Directional Truck Travel Time Index (TTTI). The industry standard definition for TTTI is the ratio of average peak period travel time to free-flow travel time. The TTTI reflects the extra time spent in traffic during peak times due to recurring delay. Recurring delay refers to expected or normal delay due to roadway capacity constraints or traffic control devices.

Similar to the TPTI, the TTTI can be converted into a speed-based index by recognizing that speed is equal to distance traveled divided by travel time. The speed-based TTTI can be calculated using the following formula:

TTTI = Free-Flow Truck Speed / Observed Average Peak Period Truck Speed

Observed average peak period truck speeds are available in the 2014 American Digital Cartography, Inc. HERE (formerly NAVTEQ) database to which ADOT has access. The free-flow truck speed is assumed to be 65 mph or the posted speed, whichever is less.

For each corridor segment, the TTTI is calculated for each direction of travel. With the TTTI, the higher the TTTI value is above 1.0, the more time is spent in traffic during peak times. TTTI values are generally lower than TPTI values. The Directional TTTI scale is based on TTTI scales created previously by ADOT.

The scale for rating the Directional TTTI is:

Uninterrupted Flow Facilities

- Good: < 1.15
- Fair: 1.15 – 1.33
- Poor: > 1.33

Interrupted Flow Facilities

- Good: < 3.00
- Fair: 3.00-6.00
- Poor: > 6.00

Road Closures (Directional Closure Duration)

The performance measure related to road closures is average roadway closure (i.e., full lane closure) duration time. There are three main components to full closures that affect reliability – frequency, duration, and extent. In the freight industry, closure duration is the most important component because trucks want to minimize travel time and delay.

Data on the frequency, duration, and extent of full roadway closures on the ADOT State Highway System is available for 2010-2014 in the Highway Condition Reporting System (HCRS) database that is managed and updated by ADOT.

The average closure duration in a segment – in terms of the average time a milepost is closed per mile per year on a given segment is calculated using the following formula:

*Closure Duration = Sum of Segment (Closure Clearance Time * Closure Extent) / Segment Length*

The segment closure duration time in hours can then be compared to statewide averages for closure duration in hours, with one standard deviation from the average forming the scale break points. The scale for rating closure duration in hours is:

- Good: < 44.18 Minutes
- Fair: 44.18 Minutes – 124.86 Minutes
- Poor: > 124.86 Minutes

Bridge Vertical Clearance

This secondary measure uses the vertical clearance information from the ADOT Bridge Database to identify locations with low vertical clearance. The minimum vertical clearance for all underpass structures is determined for each segment. The performance thresholds for the Bridge Vertical Clearance are as follows:

- Good: > 16.5'
- Fair: 16.0'-16.5'
- Poor: < 16.0'

Truck Restriction Hot Spots (Vertical Clearance)

The performance measure related to truck restrictions is the number of locations, or "hot spots", where vertical clearance issues restrict truck travel. Sixteen feet is the minimum standard vertical clearance value for interstate bridges.

Structures with vertical clearance values less than 16 feet as identified in the ADOT Bridge Database are considered low clearance bridges and for the purposes of this evaluation are categorized as poor performing. These locations where ramps do not exist so that the low clearance structure can be avoided are considered 'Hot Spots' for the Freight Performance Area. These structures are mapped on the Primary Freight Index Map to identify their geographic location within the I-10/SR 85 corridor.

3.5.3 I-10/SR 85 Freight Performance

The Freight Index and secondary performance measures were calculated for the I-10/SR 85 corridor as described in the previous section. The Freight Index, Travel Time Index, and Planning Time Index were calculated based on HERE data provided by ADOT for 2014 and the closure data was provided by ADOT for 2010 to 2014. The Freight Index provides a top-level assessment of the freight mobility for the corridor and for each segment. The four supplemental measures provide more detailed information to assess the freight performance for each segment. The resulting scores are shown in **Table 7**.

The results for the Freight Index and secondary measures are shown in **Figure 28** through **Figure 32**.

Based on the results of this analysis, the following observations could be made:

- Overall, based on the weighted average of the Freight Index, the freight mobility is in "good" condition
- Slightly more than half of the segments show "good" performance in the Freight Index, and the majority show "good" performance in directional TTTI and TPTI
- The majority of the segments along the SR 85 portion of the corridor show "poor" or "fair" condition for TTTI and TPTI.
- A majority of the segments show "good" performance in the closure performance measure
- Segments 4, 6, 7, 9, and 10 have the longest duration of closures
- There are two locations along the corridor that have a vertical clearance restriction that cannot be by-passed by using ramps, Ramsey Mine Road UP (MP33) and 355th Avenue UP (MP 101).

Table 7: Freight Performance Summary

Segment	Segment Length (miles)	Freight Performance Area							
		Freight Index	Directional TTI (trucks only)		Directional PTI (trucks only)		Closure Duration (hours/mile/year)		Bridge Vertical Clearance
			NB/WB	EB/SB	NB/WB	EB/SB	NB/WB	EB/SB	
10W-1	16	0.71	1.14	1.19	1.36	1.46	50.47	25.03	16.11
10W-2	6	0.89	1.05	1.04	1.13	1.11	43.57	4.80	15.96
10W-3	10	0.89	1.05	1.04	1.14	1.10	8.78	60.66	16.14
10W-4	22	0.90	1.04	1.05	1.09	1.12	35.48	136.64	15.90
10W-5	17	0.87	1.06	1.06	1.17	1.13	42.00	59.85	16.25
10W-6	11	0.90	1.06	1.05	1.11	1.12	100.12	97.78	16.00
10W-7	16	0.88	1.05	1.06	1.13	1.15	197.56	36.99	16.58
10W-8	15	0.90	1.04	1.04	1.11	1.12	44.39	31.35	15.92
85-9	6	0.66	1.00	1.07	1.40	1.64	17.87	187.62	No UP
85-10	11	0.73	1.11	1.00	1.71	1.03	93.75	0.00	No UP
85-11	15	0.65	1.06	1.15	1.15	1.94	21.20	4.17	No UP
85-12	3	0.60	1.00	1.19	1.00	2.35	30.67	5.33	No UP
85-13	2	0.14	2.17	1.47	12.08	2.59	No Data		16.63
85-14	3	0.17	1.27	1.91	8.04	3.82	No Data		No UP
Weighted Average		0.80							

Uninterrupted					
Good	> 0.77	< 1.15	< 1.30	< 44.18	> 16.5
Fair	0.67 – 0.77	1.15 – 1.33	1.30 – 1.50	44.18 – 124.86	16.0 – 16.5
Poor	< 0.67	> 1.33	> 1.50	> 124.86	< 16.0
Interrupted					
Good	>0.33	<1.30	<3.0	<44.18	>16.5
Fair	0.17-0.33	1.30-2.0	3.0-6.0	44.18-124.86	16.0-16.5
Poor	<0.17	>2.0	>6.0	>124.86	<16.0

Figure 28: Freight Index

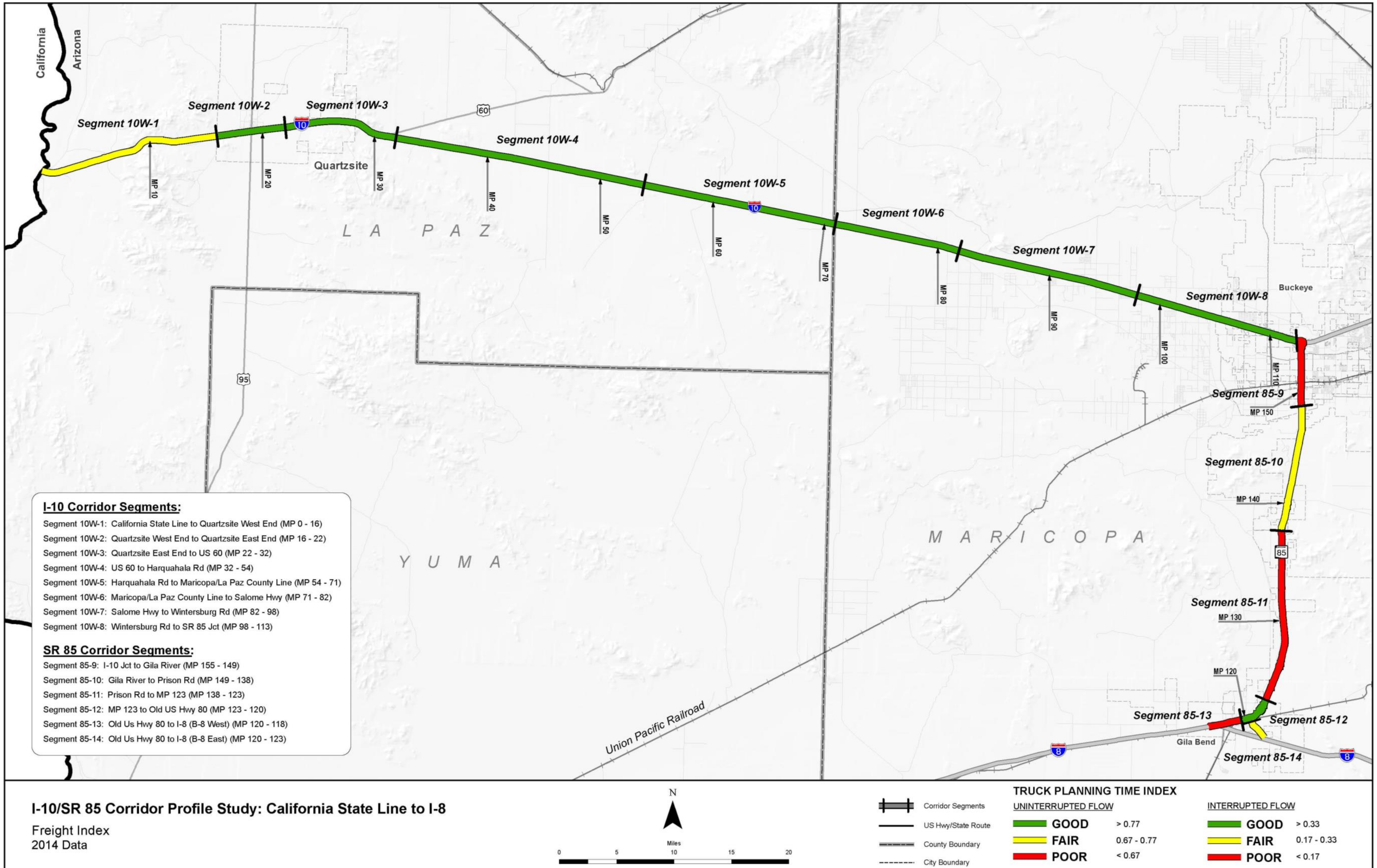


Figure 29: Truck Travel Time Index

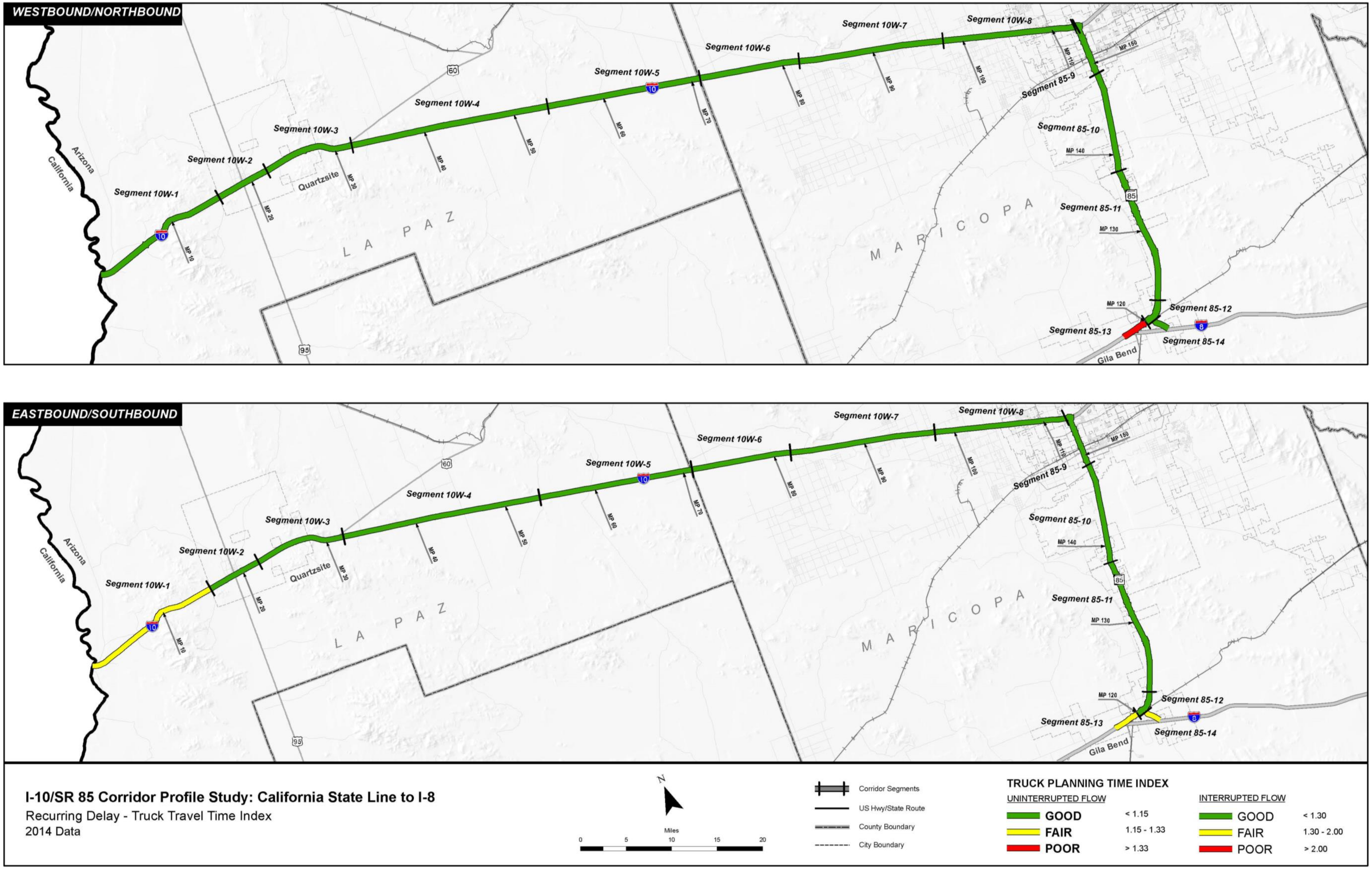


Figure 30: Truck Planning Time Index

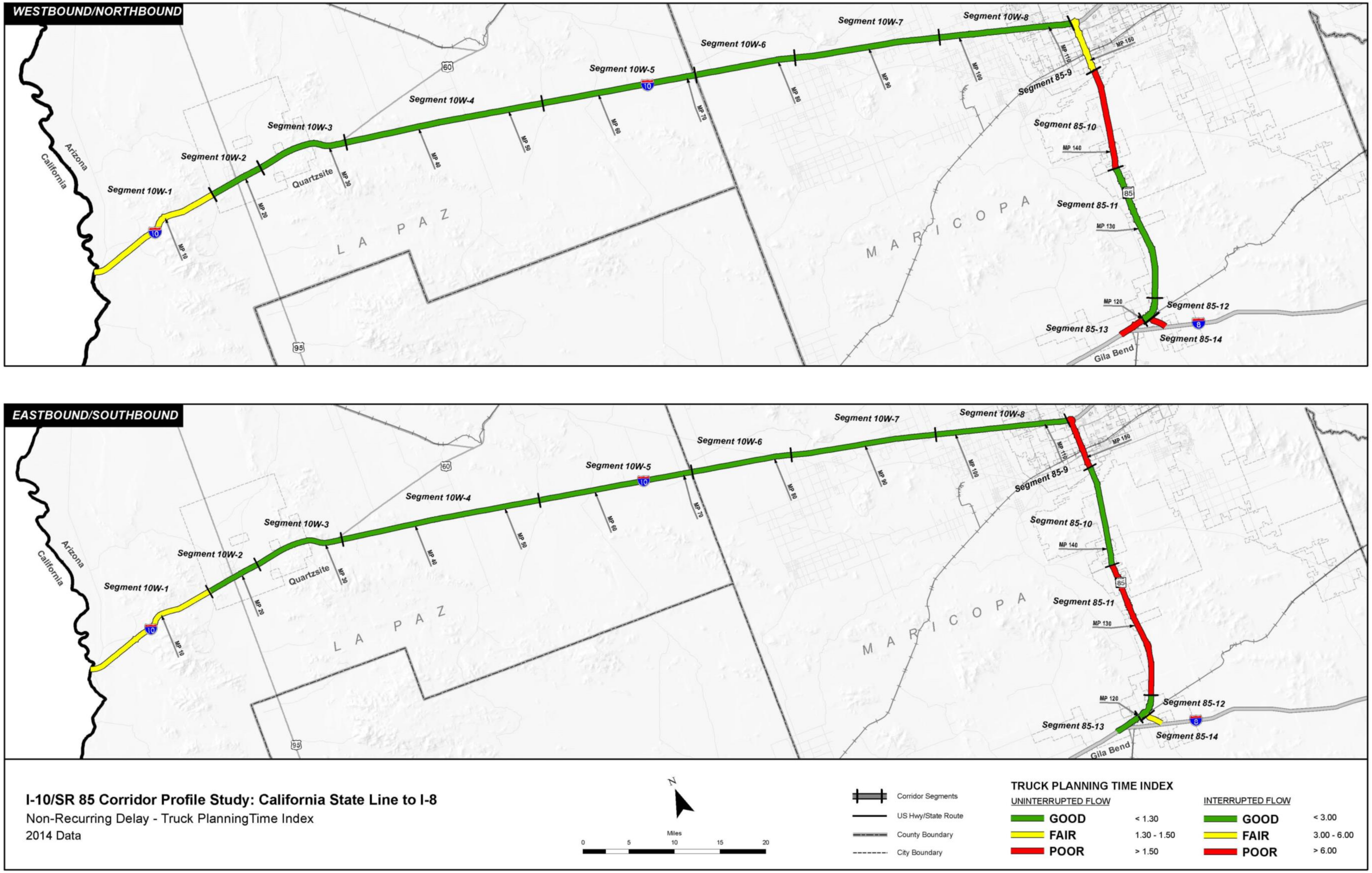


Figure 31: Duration of Closure

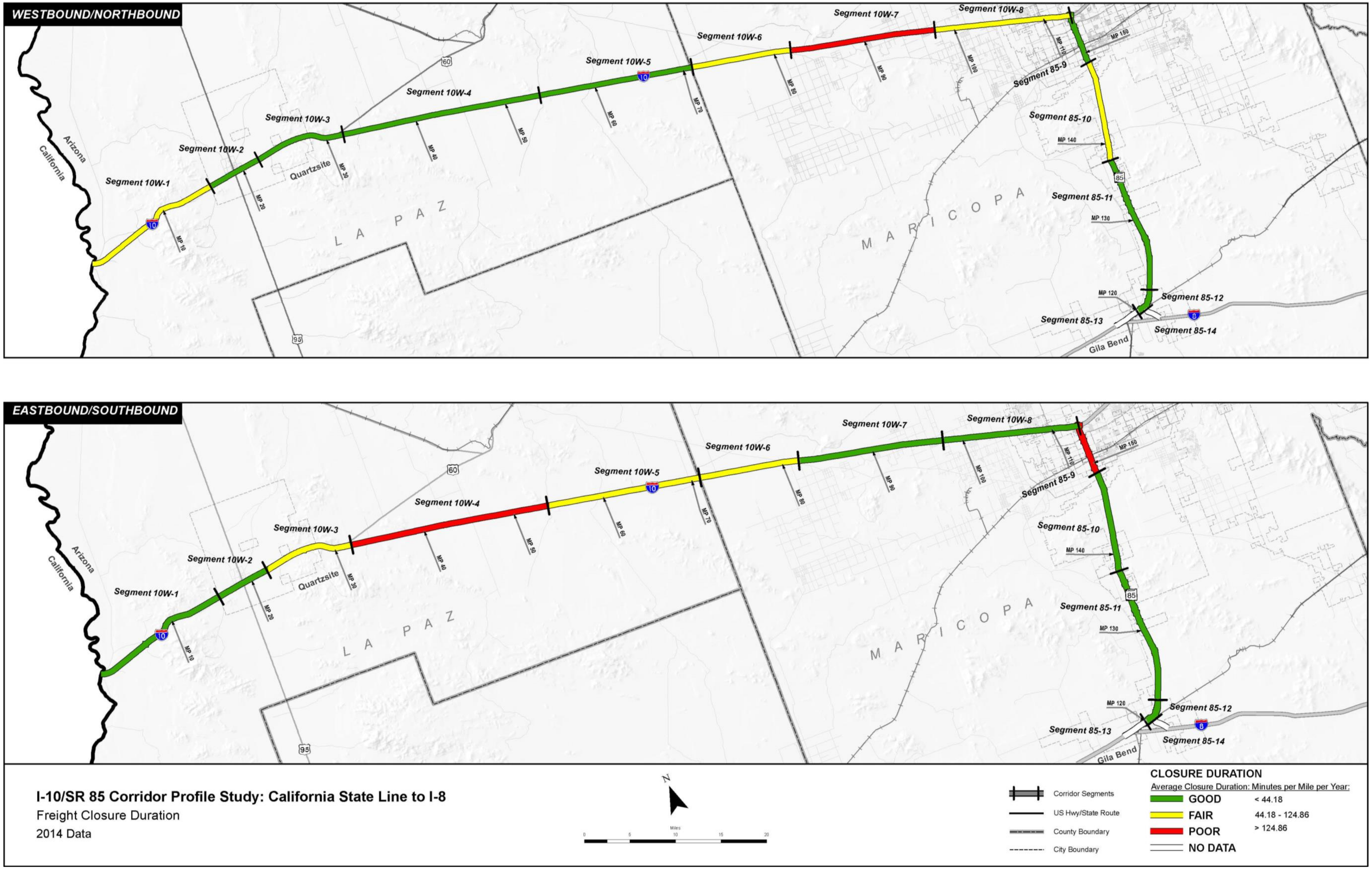
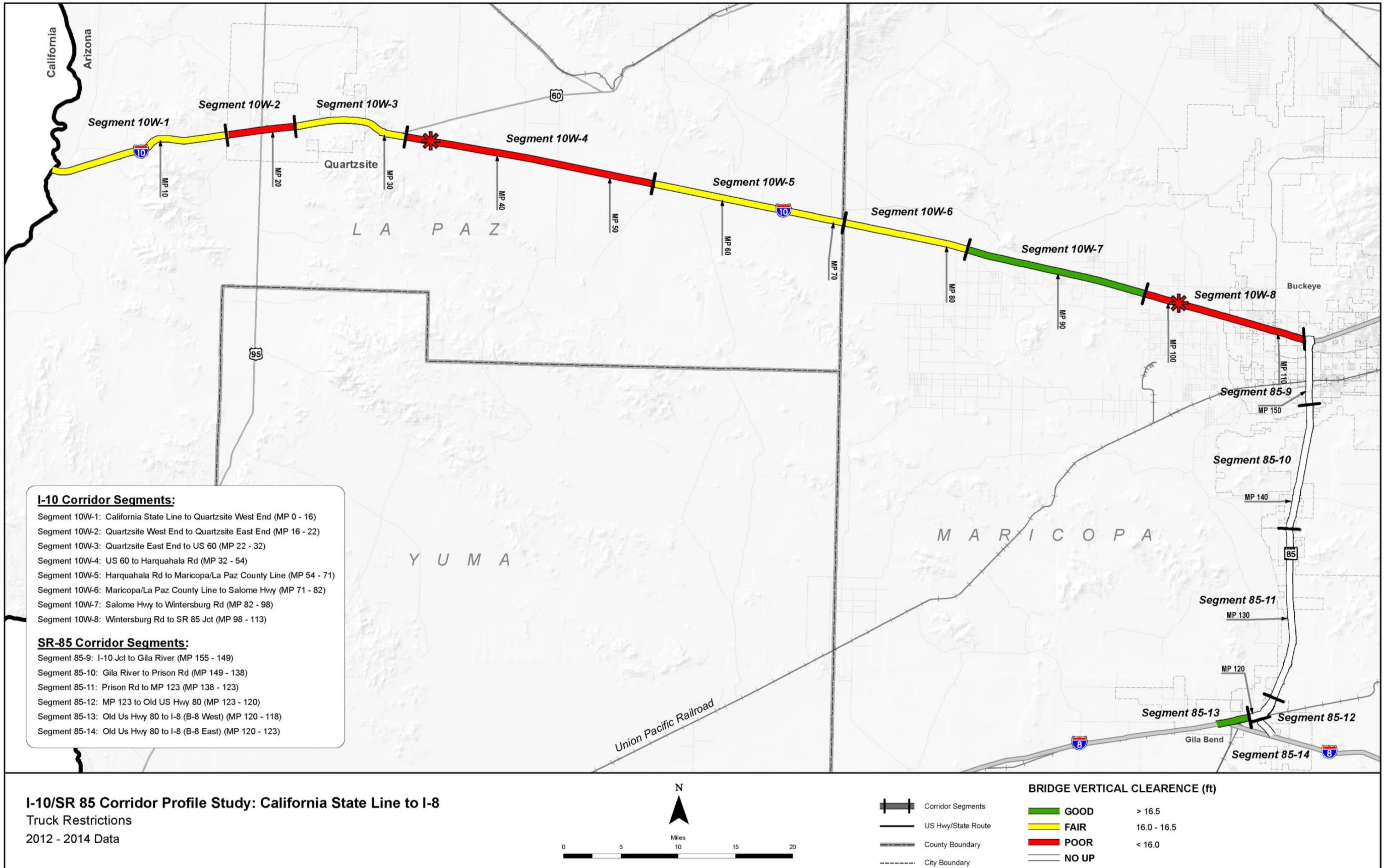


Figure 32: Bridge Vertical Clearance



4. CORRIDOR HEALTH SUMMARY

Based on the results presented in the preceding sections, the following general observations could be made related to the performance of the I-10/SR 85 corridor:

- The pavement is generally in “good” condition with the exception of a few isolated locations
- The bridges are generally in “fair” condition overall with only eight bridges with a single rating of 5 along the corridor.
- The general mobility and freight indices along the corridor are displaying “good” performance where both are also showing very little recurring and non-recurring delays along the I-10 portion of the corridor. The segments along SR 85 show elevated levels of delay in the southern end of the corridor.
- The closures along the corridor are generally lower than the statewide average for both the closure frequency and duration, however there is one outlier in segment 9 in the southbound direction
- Overall, based on the weighted average of the Safety Index, the corridor rates in “below average performance” condition.
- There are a few hot spot crashes throughout the corridor in segments 3 through 9.

Figure 33 shows the percentage of the I-10/SR 85 corridor that rates either “good”, “fair”, or “poor” in each Performance Area Primary Index. 94% of the corridor segments show “good” performance in the Pavement Index. Approximately 96% of the segments show “good” performance in Mobility, while the remaining 4% show “poor” performance. In the Freight Index, approximately 65% of the segments show “good” performance, while 20% is rated “fair” and 15% is rated “poor”. The Bridge index displays only 30% of the segments in “good” condition, and 70% in “fair” condition. Almost half of the corridor segments in the Safety index show as “below average” condition, where 31% of the segments show as “average” condition, and only 22% are in “above average” condition.

It appears that the lowest performance along the I-10/SR 85 corridor occurs in the Bridge and Safety Performance Areas while the Pavement and Mobility Performance Areas showing the highest performance.

A summary of the Index level performance is shown in **Figure 34**. **Table 8** shows a summary of all primary and secondary performance measures for the I-10/SR 85 corridor.

A weighted average rating (based on the length of the segment) was calculated for each primary and secondary measure as shown in **Table 8**. The weighted average ratings are summarized in **Figure 35**, which represents the average for the entire corridor for each measure.

Figure 33: Performance Index Distribution

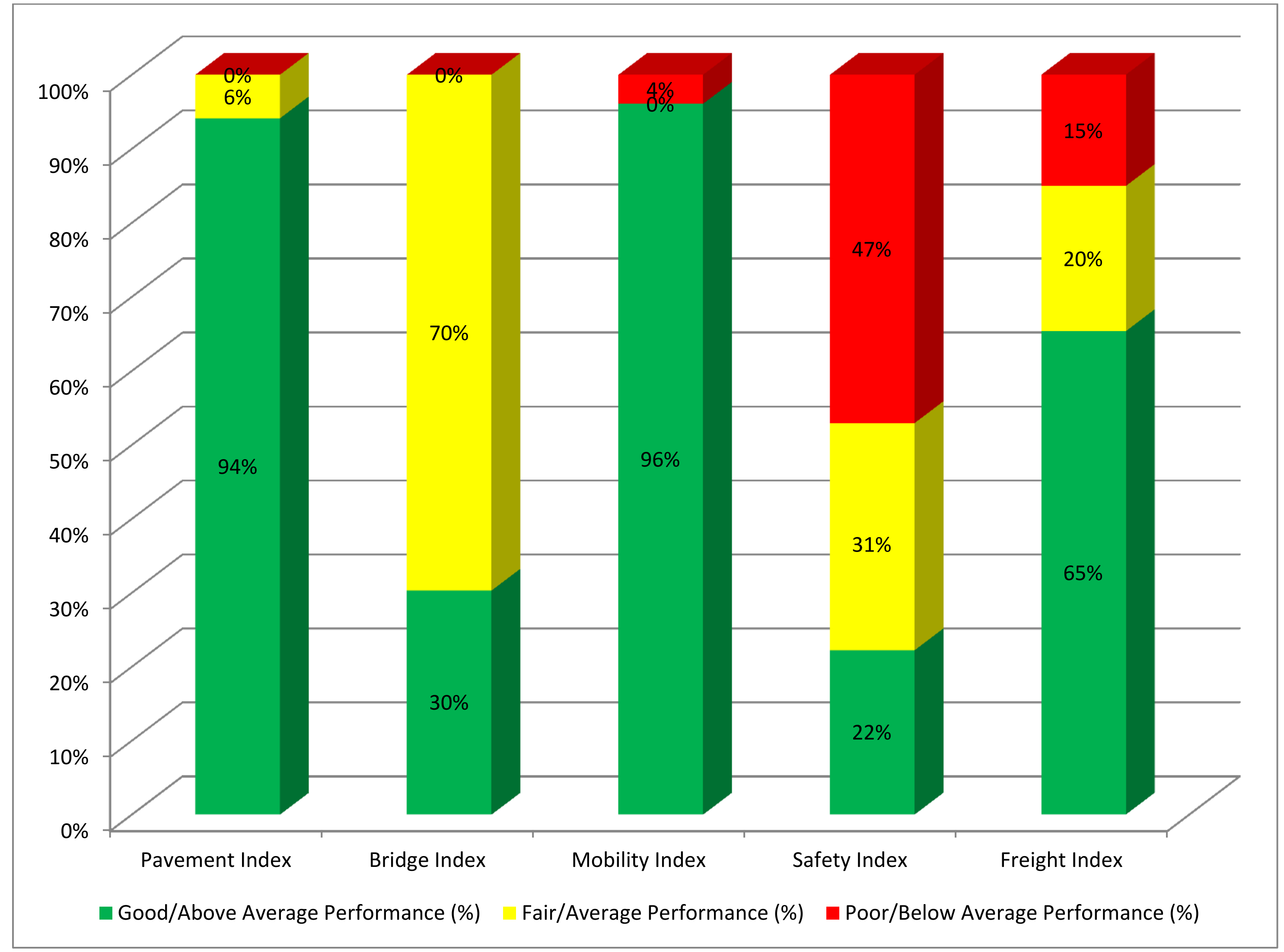
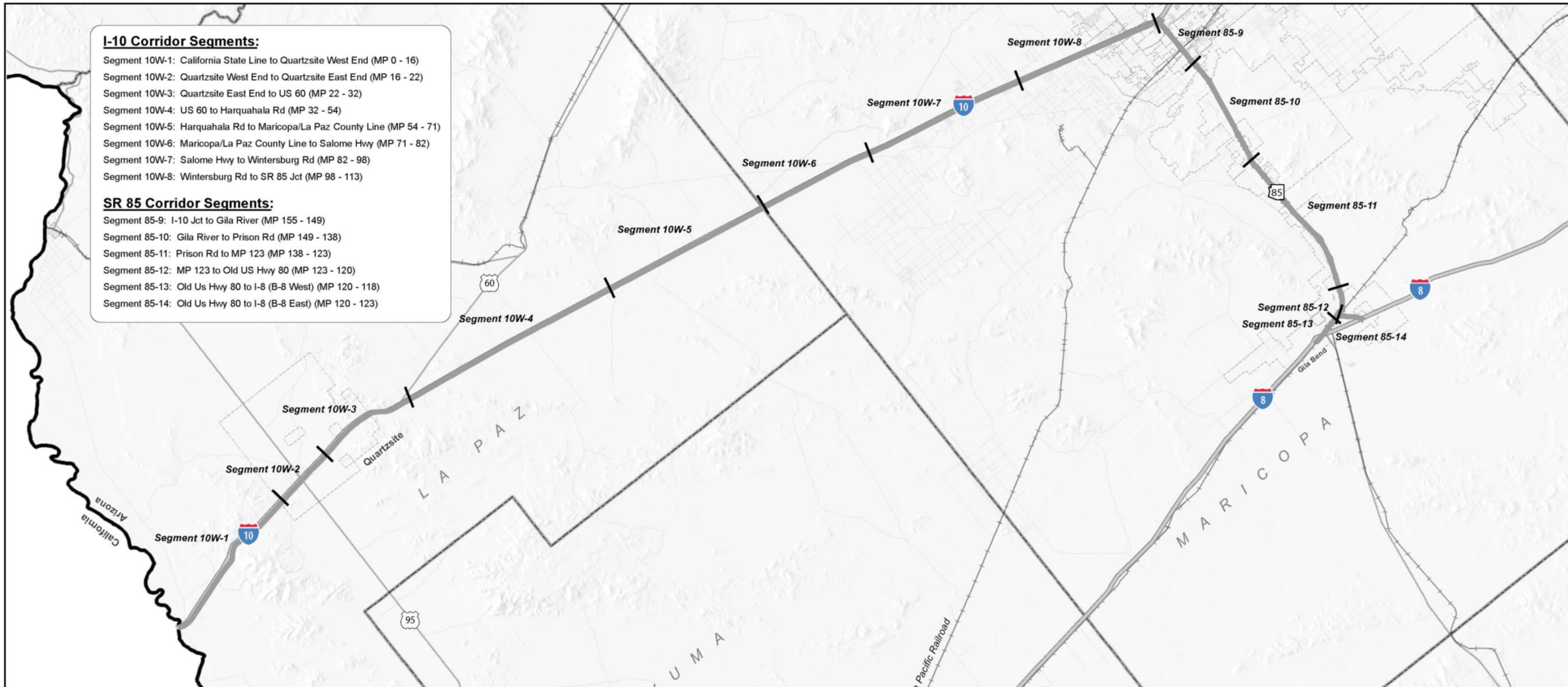


Figure 34: I-10/SR 85 Corridor Performance Index Summary



PERFORMANCE SUMMARY TABLE

	10W-1	10W-2	10W-3	10W-4	10W-5	10W-6	10W-7	10W-8	85-9	85-10	85-11	85-12	85-13	85-14	Weighted Average
Pavement	3.76	3.61	3.90	3.76	4.37	3.85	3.95	3.95	4.01	3.83	3.80	3.32	No Data		3.76
Bridge	5.11	5.92	6.00	6.50	6.48	7.00	6.25	6.71	No Bridges	6.53	No Bridges	5.00	5.21	6.57	6.25
Mobility	0.27	0.30	0.27	0.31	0.29	0.29	0.32	0.53	0.30	0.23	0.17	0.92	0.32	1.01	0.33
Safety	0.76	0.99	1.03	1.79	1.60	1.66	2.60	1.05	3.12	0.54	0.26	0.11	0.17	0.00	1.31
Freight	0.71	0.89	0.89	0.90	0.87	0.90	0.88	0.90	0.66	0.73	0.65	0.60	0.14	0.17	0.80

PERFORMANCE INDEX SCALE
Above Average, Good
Average, Fair
Below Average, Poor

I-10/SR 85 Corridor Profile Study: California State Line to I-8
Performance Index Summary

N

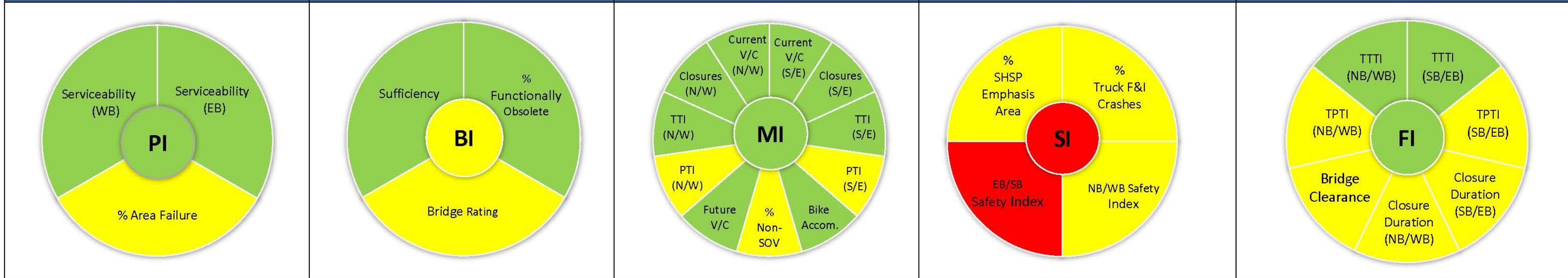
Miles 0 5 10 15 20

Table 8: I-10/SR 85 Corridor Performance Summary

Segment	Length (miles)	Pavement Performance Area: Pavement Index	Directional PSR EB/SB	Directional PSR NB/WB	Pavement Failure	Bridge Performance Area: Bridge Index	Bridge Sufficiency	Bridge Rating	Obsolete Bridges	Mobility Performance Area: Mobility Index	Future V/C	Existing Peak Hour V/C EB/SB	Existing Peak Hour V/C NB/WB	Closure Extent (instances/milepost/year/mile) EB/SB	Closure Extent (instances/milepost/year/mile) NB/WB	Directional TTI (all vehicles) EB/SB	Directional TTI (all vehicles) NB/WB	Directional PTI (all vehicles) EB/SB	Directional PTI (all vehicles) NB/WB	% Bicycle Acc.	% Non-Single Occupancy Vehicle (SOV) Opportunities
10W-1	16	3.76	3.93	3.96	13.0%	5.11	67.26	5	5.8%	0.27	0.30	0.28	0.28	0.05	0.30	1.17	1.20	1.54	1.57	100.00%	11.9%
10W-2	6	3.61	4.06	3.87	0.0%	5.92	95.30	5	9.0%	0.30	0.32	0.29	0.29	0.03	0.23	1.10	1.13	1.25	1.30	100.00%	15.2%
10W-3	10	3.90	3.97	3.88	0.0%	6.00	87.89	6	36.8%	0.27	0.29	0.28	0.28	0.18	0.08	1.10	1.15	1.24	1.34	99.00%	19.7%
10W-4	22	3.76	3.74	3.52	27.0%	6.50	97.22	5	0.0%	0.31	0.34	0.34	0.34	0.11	0.14	1.09	1.11	1.23	1.24	100.00%	10.7%
10W-5	17	4.37	4.16	4.22	0.0%	6.48	98.35	6	0.0%	0.29	0.32	0.29	0.29	0.28	0.13	1.08	1.11	1.20	1.27	100.00%	5.3%
10W-6	11	3.85	3.68	3.55	18.0%	7.00	97.41	7	0.0%	0.29	0.32	0.27	0.31	0.36	0.24	1.09	1.10	1.23	1.21	100.00%	6.1%
10W-7	16	3.95	3.94	3.81	0.0%	6.25	97.70	6	0.0%	0.32	0.36	0.29	0.34	0.11	0.40	1.10	1.10	1.23	1.24	100.00%	12.5%
10W-8	15	3.95	3.80	3.67	13.0%	6.71	96.12	5	0.0%	0.53	0.70	0.34	0.35	0.11	0.12	1.10	1.11	1.25	1.25	100.00%	14.6%
85-9	6	4.01	3.63	3.85	0.0%	NO BRIDGES IN SEGMENT				0.30	0.39	0.18	0.18	0.77	0.07	1.05	1.00	1.76	1.32	88.00%	19.3%
85-10	11	3.83	4.11	3.82	14.0%	6.53	99.47	6	0.0%	0.23	0.28	0.15	0.16	0.00	0.25	1.00	1.07	1.07	1.83	100.00%	13.6%
85-11	15	3.80	3.78	4.35	22.0%	NO BRIDGES IN SEGMENT				0.17	0.20	0.09	0.09	0.03	0.13	1.09	1.01	1.84	1.16	94.00%	8.2%
85-12	3	3.32	3.21	3.42	17.0%	5.00	83.40	5	0.00%	0.92	1.11	0.56	0.56	0.07	0.27	1.19	1.00	3.19	1.00	32.00%	8.8%
85-13	2	NO DATA AVAILABLE				5.21	86.91	5	0.0%	0.32	0.35	0.25	0.25	NO DATA AVAILABLE		1.47	1.85	4.26	ND	47.00%	9.0%
85-14	3	NO DATA AVAILABLE				6.57	92.55	5	0.0%	1.01	1.24	0.66	0.67	NO DATA AVAILABLE		1.89	1.28	4.25	9.05	42.00%	7.0%
Corridor Averages		3.76	3.88	3.85	11.69%	6.25	91.63	5.50	4.30%	0.33	0.38	0.28	0.29	0.15	0.20	1.11	1.11	1.47	1.46	96%	11%
		Urban (Rural)								Urban (Rural)						Uninterrupted (Interrupted)					
Good		≥ 3.75 (3.5)			< 5%	≥ 6.5	> 80	≥ 6	< 12%	< 0.71 (< 0.56)				< 0.22		<1.15(1.30)		<1.30(3.00)		> 90%	> 17%
Fair		3.2 - 3.75 (2.9 - 3.5)			5% - 20%	5.0 - 6.5	50 - 80	5 – 6	12% - 40%	0.71 - 0.89 (0.56 - 0.76)				0.22 - 0.62		1.15-1.33(1.3-2)		1.30-1.50(3-6)		60% - 90%	11% - 17%
Poor		≤ 3.2 (2.9)			> 20%	≤ 5.0	< 50	≤ 5	> 40 %	> 0.89 (> 0.76)				> 0.62		>1.33(2.00)		>1.50(6.00)		< 60%	< 11%

Segment	Safety Performance Area: Safety Index	Directional Safety Index EB/SB	Directional Safety Index NB/WB	% of Fatal + Incapacitating Injury Crashes Involving SHSP Top 5 Emphasis Areas Behaviors	% of Fatal + Incapacitating Injury Crashes Involving Trucks	Freight Performance Area: Freight Index	Directional TTI (trucks only) EB/SB	Directional TTI (trucks only) NB/WB	Directional PTI (trucks only) EB/SB	Directional PTI (trucks only) NB/WB	Closure Duration (hours/milepost closed/year/mile) EB/SB	Closure Duration (hours/milepost closed/year/mile) NB/WB	Bridge Vertical Clearance
10W-1	0.76	0.43	1.10	58%	8%	0.71	1.19	1.14	1.46	1.36	25.03	50.47	16.11
10W-2	0.99	0.12	1.86	40%	Insufficient Data	0.89	1.04	1.05	1.11	1.13	4.80	43.57	15.96
10W-3	1.03	1.20	0.87	54%	15%	0.89	1.04	1.05	1.10	1.14	60.66	8.78	16.14
10W-4	1.79	1.92	1.65	54%	11%	0.90	1.05	1.04	1.12	1.09	136.64	35.48	15.90
10W-5	1.60	2.08	1.12	35%	35%	0.87	1.06	1.06	1.13	1.17	59.85	42.00	16.25
10W-6	1.66	2.62	0.70	56%	17%	0.90	1.05	1.06	1.12	1.11	97.78	100.12	16.00
10W-7	2.60	1.48	3.72	40%	20%	0.88	1.06	1.05	1.15	1.13	36.99	197.56	16.58
10W-8	1.05	1.39	0.71	50%	19%	0.90	1.04	1.04	1.12	1.11	31.35	44.39	15.92
85-9	3.12	3.05	3.20	Insufficient Data	Insufficient Data	0.66	1.07	1.00	1.64	1.40	187.62	17.87	No UP
85-10	0.54	1.08	0.00	Insufficient Data	Insufficient Data	0.73	1.00	1.11	1.03	1.71	0.00	93.75	No UP
85-11	0.26	0.50	0.03	Insufficient Data	Insufficient Data	0.65	1.15	1.06	1.94	1.15	4.17	21.20	No UP
85-12	0.11	0.00	0.23	Insufficient Data	Insufficient Data	0.60	1.19	1.00	2.35	1.00	5.33	30.67	No UP
85-13	0.17	0.00	0.35	Insufficient Data	Insufficient Data	0.14	1.47	2.17	2.59	12.08	No Data		16.63
85-14	0.00	0.00	0.00	Insufficient Data	Insufficient Data	0.17	1.91	1.27	3.82	8.04	No Data		No UP
Corridor Averages	1.31	1.36	1.25	49%	17%	0.80	1.10	1.08	1.35	1.48	56.77	61.68	16.12
						Uninterrupted (Interrupted)							
Good	Varies					> 0.77(0.33)	<1.15(1.30)		<1.30(3.00)		<44.18		>16.5
Fair	Varies					.67-.77(.17-.33)	1.15-1.33(1.3-2)		1.30-1.50(3-6)		44.18-124.86		16.0-16.5
Poor	Varies					< 0.67(.17)	>1.33(2.00)		>1.50(6.00)		>124.86		<16.0

Figure 35: I-10/SR 85 Corridor Performance Summary



Pavement	Bridge	Mobility	Safety	Freight
Pavement Index (PI): based on two pavement condition ratings from the ADOT Pavement Database, International Roughness Index (IRI) and the Cracking Rating. The calculation of the Pavement Index uses a combination of these two ratings.	**Bridge Index (BI):** based on four bridge condition ratings from the ADOT Bridge Database. The four ratings are the Deck Rating, Substructure Rating, Superstructure Rating, and Structural Evaluation Rating.	**Mobility Index (MI):** an average of the current volume-to-capacity (V/C) ratio and the projected 2035 V/C ratio.	**Safety Index (SI):** combines the bi-directional frequency and rate of fatal incapacitating injury crashes, compared to crash occurrences on similar roadways in Arizona.	**Freight Index (FI):** a reliability performance measure based on the bi-directional planning time index for truck travel.
➢ **Directional Pavement Serviceability** – the weighted average (based on number of lanes) rating which measures the condition of the pavement in each direction of travel. ➢ **Pavement Failure** – the percentage of pavement area that is rated above the failure thresholds for IRI or Cracking, as established by ADOT Materials Group (IRI > 105 or Cracking > 15).	➢ **Sufficiency** – indicative of bridge sufficiency to remain in service. The factors that contribute to the Sufficiency Rating include structural adequacy and safety, serviceability and functional obsolescence, and essentiality for public use. ➢ **% Functionally Obsolete** – indicative of the percentage of deck area on bridges that is no longer functionally adequate for its current use, such as lack of shoulders or the inability to handle current traffic volumes. Functionally Obsolete does not directly relate to the structural adequacy. ➢ **Bridge Rating** – identifies the lowest rating on each segment.	➢ **Directional Current V/C** – the existing peak hour V/C ratio in both directions of the corri-dor. This measure provides an understanding of the directional operating characteristics of the corridor during the existing peak hour from a mobility congestion standpoint. ➢ **Future V/C** – a measure of the future 2035 V/C ratio that identifies how the corridor will operate in the future from a mobility congestion standpoint. ➢ **Directional Closures** – the average number of times a given location in the corridor was closed per mile in a specific direction of travel per year. ➢ **Directional Travel Time Index (TTI)** – the ratio of the average peak period travel time to the free-flow travel time. The TTI represents recurring delay along the corridor. ➢ **Directional Planning Time Index (PTI)** – the ratio of the total travel time needed for 95 percent on-time arrival to free-flow travel time. The PTI represents non-recurring delay along the corridor. ➢ **% Non-single Occupancy Vehicle Trips (Non-SOV)** – represents the percentage of trips that are taken by vehicles carrying more than one occupant. ➢ **Bicycle Accommodation** – represents the percentage of roadway that is accommodating for bicycle travel.	➢ **% SHSP Emphasis Area** – the percentage of fatal and incapacitating crashes that involve at least one of the five Strategic Highway Safety Plan (SHSP) Emphasis Areas. ➢ **Directional Safety Index** – the combination of the directional frequency and rate of fatal incapacitating injury crashes, compared to crash occurrences on similar roadways in Arizona. ➢ **% Crashes Involving Trucks** – the percentage of fatal and incapacitating crashes that involve trucks.	➢ **Directional Truck Planning Time Index (TPTI)** – the ratio of total travel time (for trucks only) needed for 95 percent on-time arrival to free-flow travel time. The TPTI represents non-recurring delay along the corridor. ➢ **Directional Truck Travel Time Index (TTTI)** – the ratio of the average peak period travel time (for trucks only) to the free-flow travel time. The TTTI represents recurring delay that occurs along the corridor. ➢ **Directional Closure Duration** – the average time a given location in the corridor was closed per mile per year. ➢ **Bridge Clearance** – the minimum vertical clearance for all underpass structures within each segment as determined via the ADOT Bridge Database.

5. AGENCY DISCUSSIONS

Meetings were held with the following agencies to review the performance framework, performance measures, and performance mapping:

- Southwest District

Input received during these meetings is summarized below by Performance Area.

Pavement Performance Area

- SR85-NB: Pavement project (started as spot repair) is currently underway on MP 121-130.4
- The travel lane (right late) MP 2-12 on I-10 WB is being patched for alligator cracking
- The travel lane (right late) MP 24-26 on I-10 EB is experiencing pavement failure; >1300 linear feet of spot repair
- Pavement preservation is happening on SR85 NB &SB at MP 42-82

Bridge Performance Area

- Everyone generally agreed with the Bridge Performance Area performance results and had no comments regarding the bridges in the corridor. However, there was a general statement made about bridges across the state regarding their clearances being far too low.
- It was noted that the Ramsey Mine Road UP low clearance issue may be by-passed by using Exit #45 via US 60.

Mobility Performance Area

- Regarding the outlier in Segment 13 PTI NB: Perhaps there was construction happening in 2013/2014 when the data was being collected, and there was note of a school possibly being in that segment

Safety Performance Area

- Comments were made suggesting the low safety scores could be due to:
  - Elevated interchanges
  - Trucks pulling out in front of traffic while going up-hill
  - Segments 1-3 endure many high-speed chases from California

Freight Performance Area

- Part of an upcoming pavement preservation project will include lowering road profile to address the low clearance issue at Ramsey Mine Rd

General Comments

- Everyone generally agreed with all performance system results
- Representatives from ADOT noted the importance of leaving segments 13 and 14 (B-8) in the study for future projects and improvements to the corridor

Appendix A – Methodology Modifications

Rounds 1 and 2 of the corridor profile studies developed a methodology for assessing the performance of six corridors (I-17, I-19, I-40 West, I-8, I-40 East, and SR 95) in five performance areas (pavement, bridge, mobility, safety, and freight). Round 3 involves five new corridors (I-10 West/SR 85, I-10 East, US 60/US 70, US 60/US 93, and SR 87/SR 260/SR 377). Lessons learned from subsequent tasks of Rounds 1 and 2 have resulted in the following refinements to the performance methodology that will be applied to Round 3:

A. Pavement

No modifications have been made to the Pavement methodology for Round 3.

B. Bridge

No modifications have been made to the Bridge methodology for Round 3.

C. Mobility

- Capacity calculations – Some errors were discovered in some of the assumptions made in Round 2 related to the factors and equations that comprise the capacity estimation methodology known as the Highway Economic Requirements System (HERS) that the Federal Highway Administration (FHWA) recently developed. The capacity estimation equations utilized in Round 3 have been updated to correct these errors. These updates affect the Mobility Index, Peak Hour V/C, and Future Daily V/C performance measures. More information on the HERS methodology is provided in the Mobility performance area methodology write-up.
- TTI/PTI on interrupted flow facilities – Through Round 2, only two of the six corridors included segments with interrupted flow conditions. With Round 3, four additional corridors include segments with interrupted flow conditions. This increase in sample size provided the opportunity to reassess the performance thresholds developed in Round 2 for travel time index (TTI) and planning time index (PTI) on interrupted flow facilities. It was determined that for Round 3 interrupted flow segments, the TTI thresholds do not need to be modified while the PTI thresholds do need to be modified. The thresholds shown in Table C-1 show the TTI and PTI thresholds that apply to Round 3:

Table C-1: TTI and PTI Performance Thresholds for Interrupted Flow Facilities

Performance Level	TTI	PTI
Good	<1.3	<3.0
Fair	1.3 – 2.0	3.0 – 6.0
Poor	>2.0	>6.0

- Closure extent – During Round 2, it was determined that there were opportunities to refine the filtering of the closure data extracted from ADOT's Highway Condition Reporting System (HCRS) to more accurately depict the number and extent of full closures. When an updated closure data set was obtained, the closure extent thresholds were reassessed and adjusted based on statewide closure extent averages. The thresholds shown in Table C-2 show the closure extent thresholds that apply to Round 3:

Table C-2: Closure Extent Performance Thresholds

Performance Level	Occurrences per Mile per Year
Good	<0.22
Fair	0.22 – 0.62
Poor	>0.62

D. Safety

- Hot spot mapping – No changes have been made to the safety hot spot mapping methodology for Round 3, but the safety hot spots are now included on the Directional Safety Index figure rather than being shown on a separate figure.

E. Freight

- TTTI/TPTI on interrupted flow facilities – The Truck TTI (TTTI) and Truck PTI (TPTI) thresholds for interrupted flow facilities were reassessed using the additional data available on the Round 3 corridors. The thresholds shown in Table E-1 show the TTTI and TPTI thresholds that apply to Round 3 (which are consistent with the Round 3 TTI and PTI thresholds):

Table E-1: TTTI and TPTI Performance Thresholds for Interrupted Flow Facilities

Performance Level	TTTI	TPTI
Good	<1.3	<3.0
Fair	1.3 - 2.0	3.0 - 6.0
Poor	>2.0	>6.0

- Freight Index on interrupted flow facilities – The Freight Index is the inverse of the TPTI, so the aforementioned changes to the TPTI thresholds for interrupted flow facilities correspondingly affect the Freight Index thresholds for Round 3. The thresholds shown in Table E-2 show the Freight Index thresholds that apply to Round 3:

Table E-2: Freight Index Performance Thresholds for Interrupted Flow Facilities

Performance Level	Freight Index
Good	>0.33
Fair	0.17 – 0.33
Poor	<0.17

- Bridge vertical clearance secondary measure – A new secondary measure was developed for Round 3 that addresses the minimum vertical clearance of bridge underpasses over the mainline travel lanes. Bridge vertical clearance was addressed previously in Rounds 1 and 2 as a hot spot but not as a secondary measure. More information on the bridge vertical clearance secondary measure methodology is provided in the Freight performance area methodology write-up. The thresholds shown in Table E-3 show the bridge vertical clearance thresholds that apply to Round 3:

Table E-3: Bridge Vertical Clearance Thresholds

Performance Level	Vertical Clearance
Good	>16.'5
Fair	16.0' – 16.5'
Poor	<16.0

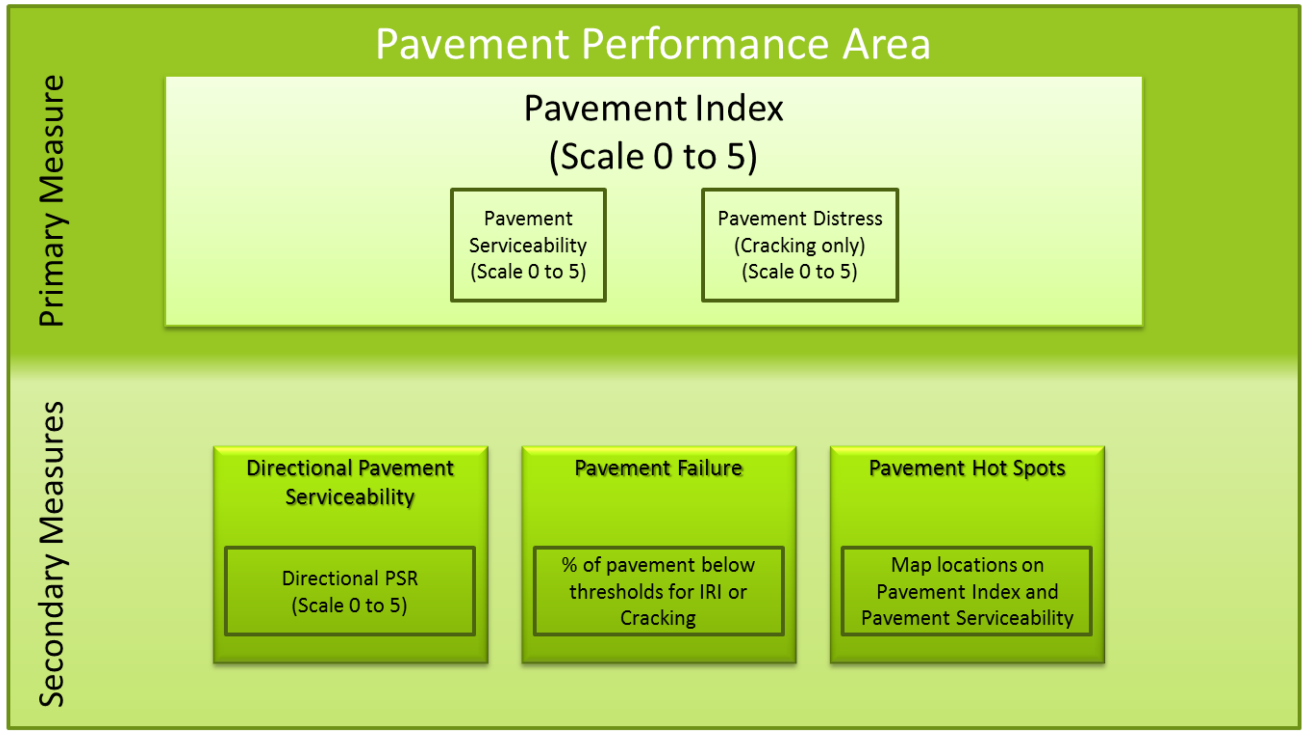
- Bridge vertical clearance hot spot – The bridge vertical clearance threshold considered a hot spot has been modified from 16 feet to 16 feet 3 inches. This change in dimensions reflects the change in measuring the bridge vertical clearance from using the posted minimum vertical clearance in Round 2 to using the actual minimum vertical clearance over a travel lane in Round 3. This change provides more consistency in how vertical clearance is measured as it was determined that posted minimum vertical clearances are generally – but not always – three inches below the actual clearance.
- Closure duration – During Round 2, it was determined that there were opportunities to refine the filtering of the closure data extracted from ADOT's Highway Condition Reporting System (HCRS) to more accurately depict the duration of full closures. When an updated closure data set was obtained, the closure duration thresholds were reassessed and adjusted based on statewide closure duration averages. The thresholds shown in Table E-4 show the closure duration thresholds that apply to Round 3:

Table E-4: Closure Duration Performance Thresholds

Performance Level	Minutes of Closure per Mile per Year
Good	<44.18
Fair	44.18 – 124.86
Poor	>124.86

Appendix B – Performance Area Instructions

Pavement Performance Area Calculation Methodologies



Primary Measure:
The Pavement Index is calculated based on the use of two pavement condition ratings from the ADOT Pavement Database. The two ratings are the International Roughness Index (IRI) and the Cracking Rating. The calculation of the Pavement Index uses a combination these two ratings.

The IRI is a measurement of the pavement roughness based on field-measured longitudinal roadway profiles. To facilitate the calculation of the index, the IRI rating was converted to a Pavement Serviceability Rating (PSR) using the following equation:

$$PSR = 5 * e^{-0.0038*IRI}$$

The Cracking Rating is a measurement of the amount of surface cracking based on a field-measured area of 1,000 square feet that serves as a sample for each mile. To facilitate the calculation of the index, the Cracking Rating was converted to a Pavement Distress Index (PDI) using the following equation:

$$PDI = 5 - (0.345 * C^{0.66})$$

Both the PSR and PDI use a 0 to 5 scale with 0 representing the lowest performance and 5 representing the highest performance. The performance thresholds shown in the tables below were used for the PSR and PDI.

Table 1 - Performance Thresholds for Interstates

	IRI (PSR)	Cracking (PDI)
Good	<75 (>3.75)	<7 (>3.75)
Fair	75 - 117 (3.20 - 3.75)	7 - 12 (3.22 - 3.75)
Poor	>117 (<3.20)	>12 (<3.22)

Table 2 - Performance Thresholds for Non-Interstates

	IRI (PSR)	Cracking (PDI)
Good	<94 (>3.5)	<9 (>3.5)
Fair	94 - 142 (2.9 - 3.5)	9 - 15 (2.9 - 3.5)
Poor	>142 (<2.9)	>15 (<2.9)

The PSR and PDI are calculated for each 1-mile section of roadway. If PSR or PDI falls into a poor rating (<3.2 for Interstates, for example) for a 1-mile section, then the score for that 1-mile section is entirely (100%) based on the lower score (either PSR or PDI). If neither PSR or PDI fall into a poor rating for a 1-mile section, then the score for that 1-mile section is based on a combination of the lower rating (70% weight) and the higher rating (30% weight). The end result is a score between 0 and 5 for each direction of travel of each mile of roadway based on a combination of both the PSR and the PDI.

The project corridor has been divided into segments. The Pavement Index for each segment is a weighted average of the directional ratings based on the number of travel lanes. Therefore, the condition of a section with more travel lanes will have a greater influence on the resulting segment Pavement Index than a section with fewer travel lanes.

The resulting Pavement Index (good/fair/poor) for each segment will be presented on a corridor map. In addition, the calculated Pavement Index for each segment will be presented in tabular format.

Secondary Measures:
Two secondary measures will be evaluated:

- Directional Pavement Serviceability
- Pavement Failure

Directional Pavement Serviceability: Similar to the Pavement Index, the Directional Pavement Serviceability will be calculated as a weighted average (based on number of lanes) for each segment. However, this rating will only utilize the PSR and will be calculated separately for each direction of travel. The PSR uses a 0 to 5 scale with 0 representing the lowest performance and 5 representing the highest performance. The resulting Directional Pavement Serviceability (good/fair/poor) for each direction of each segment will be presented on a corridor map. In addition, the calculated Directional Pavement Serviceability for each segment will be presented in tabular format.

Pavement Failure: The percentage of pavement area rated above the failure thresholds for IRI or Cracking will be calculated for each segment. The calculated percentage for each segment will be presented in a table. In addition, the Standard score (z-score) will be calculated for each segment.

The Standard score (z-score) is the number of standard deviations above or below the mean. Therefore, a Standard score between -0.5 and +0.5 is "average", less than -0.5 is lower (better) than average, and higher than +0.5 is above (worse) average. The resulting Standard Score (better/average/worse) for each segment will be presented on a corridor map. The thresholds for this performance measure have been established based on the first six corridors.

Hot Spot Identification:

The Pavement Index map will identify locations that have an IRI rating or Cracking rating that fall above the failure threshold as identified by ADOT Pavement Group. For Interstates, an IRI rating above 105 or a Cracking rating above 15 will be used as the thresholds which are slightly different than the ratings shown in the table above. For non-Interstates, an IRI rating above 142 or a Cracking rating above 15 will be used as the thresholds. The locations will be identified by displaying a symbol on the map. A single symbol will be used to represent consecutive/adjacent sections. However, if there is a gap between the sections, then a second symbol will be displayed on the map.

The Directional Serviceability map will identify locations that have an IRI rating above 105 for Interstates or above 142 for non-Interstates by displaying a symbol and labeling the location. A single symbol will be used to represent consecutive/adjacent sections. However, if there is a gap between the sections, then a second symbol will be displayed on the map.

Data Entry:

Note: Data should only be entered into cells that are colored blue.

1. If necessary, rows can be added or deleted from each segment. If rows are added, copy the formulas in columns K through U. In addition, if rows are added, verify that the formulas below each segment (weighted average and total # of lanes) are using the correct rows.
2. Enter the beginning milepost for Mile 1 of each segment (in column B) and the other mileposts should auto-calculate.
3. Adjacent to each segment title (in column E), select "Yes" if the segment is an Interstate or "No" if it is not an Interstate.
4. Edit the titles at the top of the table (row 1) to reflect the directions of travel.
5. Copy and paste 2 pavement ratings (IRI and Cracking) for each 1-mile section into the appropriate cells; use the "match destination format" command to not overwrite formatting.
6. If the 1-mile section does not have a Cracking rating, enter 0.1 into the cell for Cracking.
7. Enter the number of lanes for each 1-mile section into columns labeled "# of Lanes" (columns E and H); it is suggested that this number be a rounded approximation and should not be based on as-builts.
8. If the segment is not divided and only has pavement condition data for one direction, make sure to not have any values in the "# of Lanes" column for the direction without any data.
9. If segments are added, the formulas can be copied from another segment. However, the formulas in columns R, S, and U will need to have the references fixed as they refer to the "Interstate" question at the top of each segment.

Calculations:

1. Columns K through N calculate the PSR and PDI for each 1-mile section for each direction of travel
2. Columns O and P calculate a composite rating for each 1-mile section based on a combination of PSR and PDI
3. The weighted average Pavement Index (weighted by number of lanes) is calculated in Column Q
4. The weighted average PSR (weighted by number of lanes) is calculated in Columns K and M
5. The % of pavement above the thresholds for failure is calculated in Column S

Resulting Values and Presentation:

1. Pavement Index rating for each segment (good/fair/poor) presented on map with symbol at locations of failing pavement (either IRI or Cracking). The hot spot locations will show up in Column R or S of the spreadsheet.
2. Pavement Index score presented in table.
3. Directional Pavement Serviceability for each segment in each direction (good/fair/poor) presented on map with symbol at locations that have an IRI above 105 for Interstates or above 142 for non-Interstates. The hot spot locations will show up in Column R or S of the spreadsheet. However, only show the locations that are due to IRI rating, not the Cracking rating.
4. Directional Pavement Serviceability score presented in table.
5. % Failing Pavement; % presented in table and performance (above/average/below) presented on map.

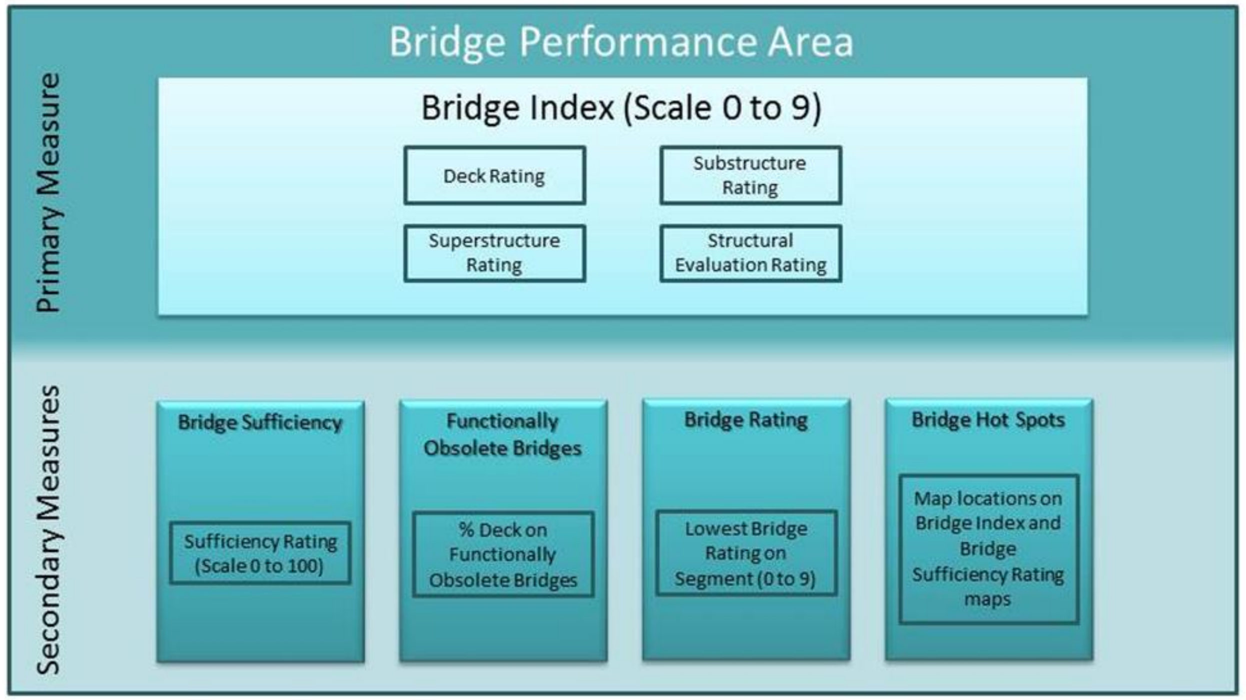
Scoring:

	Pavement Index	
	Interstates	Non-Interstates
Good	>3.75	>3.5
Fair	3.2 - 3.75	2.9 - 3.5
Poor	<3.2	<2.9

	Directional Pavement Serviceability	
	Interstates	Non-Interstates
Good	>3.75	>3.5
Fair	3.2 - 3.75	2.9 - 3.5
Poor	<3.2	<2.9

% Pavement Failure	
Better	< 5%
Average	5% – 20%
Worse	>20%

Bridge Performance Area Calculation Methodologies



This performance area is used to evaluate mainline bridges. Bridges on ramps (that do not cross the mainline), frontage roads, etc. should not be included in the evaluation. Basically, any bridge that carries mainline traffic or carries traffic over the mainline should be included and bridges that do not carry mainline traffic, run parallel to the mainline (frontage roads), or do not cross the mainline should not be included.

Primary Measure:
The Bridge Index is calculated based on the use of four bridge condition ratings from the ADOT Bridge Database, also known as the Arizona Bridge Information and Storage System (ABISS). The four ratings are the Deck Rating (N58), Substructure Rating (N60), Superstructure Rating (N59), and Structural Evaluation Rating (N67). The calculation of the Bridge Index uses the lowest of these four ratings.

Each of the four condition ratings use a 0 to 9 scale with 0 representing the lowest performance and 9 representing the highest performance.

The project corridor has been divided into segments and the bridges are grouped together according to the segment definitions. In order to report the Bridge Index for each corridor segment, the Bridge Index for each segment is a weighted average based on the deck area for each bridge. Therefore, the condition of a larger bridge will have a greater influence on the resulting segment Bridge Index than a smaller bridge.

The resulting Bridge Index (good/fair/poor) for each segment will be presented on a corridor map. In addition, the calculated Bridge Index for each segment will be presented in tabular format.

Secondary Measures:
Three secondary measures will be evaluated:

- Bridge Sufficiency Rating
- Bridge Rating
- Functionally Obsolete Bridges

Bridge Sufficiency Rating: Similar to the Bridge Index, the Bridge Sufficiency Rating will be calculated as a weighted average (based on deck area) for each segment. The Sufficiency Rating is a scale of 0 to 100 with 0 representing the lowest performance and 100 representing the highest performance. A rating of 80 or above represents “good” performance, a rating between 50 and 80 represents “fair” performance, and a rating below 50 represents “poor” performance. The resulting Sufficiency Rating (good/fair/poor) for each segment will be presented on a corridor map. The calculated Sufficiency Rating for each segment will be presented in tabular format.

Bridge Rating: The Bridge Rating will simply identify the lowest bridge rating on each segment. This performance measure is not an average and therefore is not weighted based on the deck area. The Bridge Index identifies the lowest rating for each bridge, as described above. This secondary performance measure will simply identify the lowest rating on each segment. Each of the four condition ratings use a 0 to 9 scale with 0 representing the lowest performance and 9 representing the highest performance. The resulting Bridge Rating (good/fair/poor) for each segment will be presented on a corridor map. The Bridge Rating for each segment will be presented in tabular format.

Functionally Obsolete Bridges: The percentage of deck area on functionally obsolete bridges will be calculated for each segment. The deck area for each bridge within each segment that has been identified as functionally obsolete will be totaled and divided by the total deck area for the segment to calculate the percentage of deck area on functionally obsolete bridges for each segment. The calculated percentage for each segment will be presented in tabular format.

The thresholds for this performance measure were determined based on the Standard score (z-score). The Standard score (z-score) is the number of standard deviations above or below the mean. Therefore, a Standard score between -0.5 and +0.5 is “average”, less than -0.5 is lower (better) than average, and higher than +0.5 is above (worse) average. The resulting performance (better/average/worse) for each segment will be presented on a corridor map. The thresholds for this performance measure have been established based on the first 6 corridors.

Hot Spot Identification:
The Bridge Index map will identify individual bridge locations that are identified as Hot Spots in the excel file by displaying a symbol and labeling the location. Hot Spots are bridges that have a single rating of 4 in any of the 4 ratings, or multiple ratings of 5 in the deck, substructure or superstructure ratings.

The Sufficiency Rating map will identify individual bridge locations that have a Sufficiency Rating less than 50 by displaying a symbol and labeling the location.

Data Entry:
Note: Only enter data for bridges that carry mainline traffic or carry traffic over the mainline. Bridges on ramps, frontage roads, etc. should not be used. In addition, structures with “SPP” or “RCB” in the name (A209) should not be entered. Use the GIS shapefile named “NBI_join_ABIS_Final” to verify the bridges either carry mainline traffic, or carry traffic over the mainline. In addition, bridges that do not have at least 3 of the 4 ratings (N58, N59, N60, N67) should not be included in the calculation (these will likely be box culverts).

Note: Data should only be entered into cells that are colored blue.

1. Use the "Filtered Data" worksheet in the bridge data file.
2. Filter by the route using the column labeled A230.
3. Use the column labeled A232 to identify the milepost of the bridge and copy the appropriate data into the corresponding segment, as described in step 4.
4. Copy and paste bridge names (A209), milepost (A232), and structure number (N8) in rows for each segment; use the "match destination formatting" command to not overwrite formatting.
5. Copy and paste 4 bridge ratings (N58, N59, N60, N67) for each bridge into the appropriate cells; use the "match destination formatting" command to not overwrite formatting. If a bridge does not have all 4 ratings, it should not be included in the calculation, as discussed above.
6. Copy and paste Sufficiency Rating (SR) for each bridge into the appropriate cells in Column G; use the "match destination formatting" command to not overwrite formatting.
7. Copy and paste Deck Area (A225) for each bridge into the appropriate cells in Column F; use the "match destination formatting" command to not overwrite formatting.
8. If the bridge has been identified as Functionally Obsolete (identified as "2" in in column labeled SD/FO), manually enter 'y' in the column labeled Functionally Obsolete (column P). Otherwise, manually enter 'n'.
9. If rows are added, copy the formulas.
10. If the formatting doesn't work, use the "format painter" tool to copy the formatting from other cells.
11. In each segment, delete any rows that do not contain data.
12. Some bridges (pedestrian or railroad) will have a Sufficiency Rating of -1. The formula for the segment average Bridge Sufficiency will need to be manually modified to not include these bridges.
13. If rows are added or deleted, verify that the formulas at the end of each segment are referencing the correct rows.

Calculations (automated):

1. Column F is the deck area and the values are added together to get a total deck area for the segment.
2. Columns H through K are the 4 bridge ratings; column L identifies the lowest value from the 4 bridge ratings.
3. The weighted average Sufficiency Rating (weighted by deck area) and the weighted average Condition Rating (weighted by deck area) are calculated.
4. Column N identifies the lowest rating in each segment.

Resulting Values and Presentation:

1. Bridge Index rating for each segment (good/fair/poor) presented on map with symbol at locations that are identified as Hot Spots in the excel file (column labeled "Hot Spots on Bridge Index map"). Hot Spots are bridges that have a single rating of 4 in any of the 4 ratings, or multiple ratings of 5 in the deck, substructure or superstructure ratings.
2. Bridge Index scores presented in table
3. Sufficiency Rating for each segment (good/fair/poor) presented on map with symbol at locations that have a Sufficiency Rating less than 50 **(don't include bridges with a -1 sufficiency rating)**
4. Sufficiency Rating scores presented in table
5. Bridge Rating for each segment (good/fair/poor) presented on map with symbol at locations that are structurally deficient
6. Bridge Rating scores presented in table
7. % Bridge Deck Area on Functionally Obsolete Bridges performance (better/average/worse) presented on map; % presented in table
8. % Bridge Deck Area on Functionally Obsolete Bridges presented in table

Scoring:

Bridge Index	
Good	>6.5
Fair	5.0-6.5
Poor	<5.0

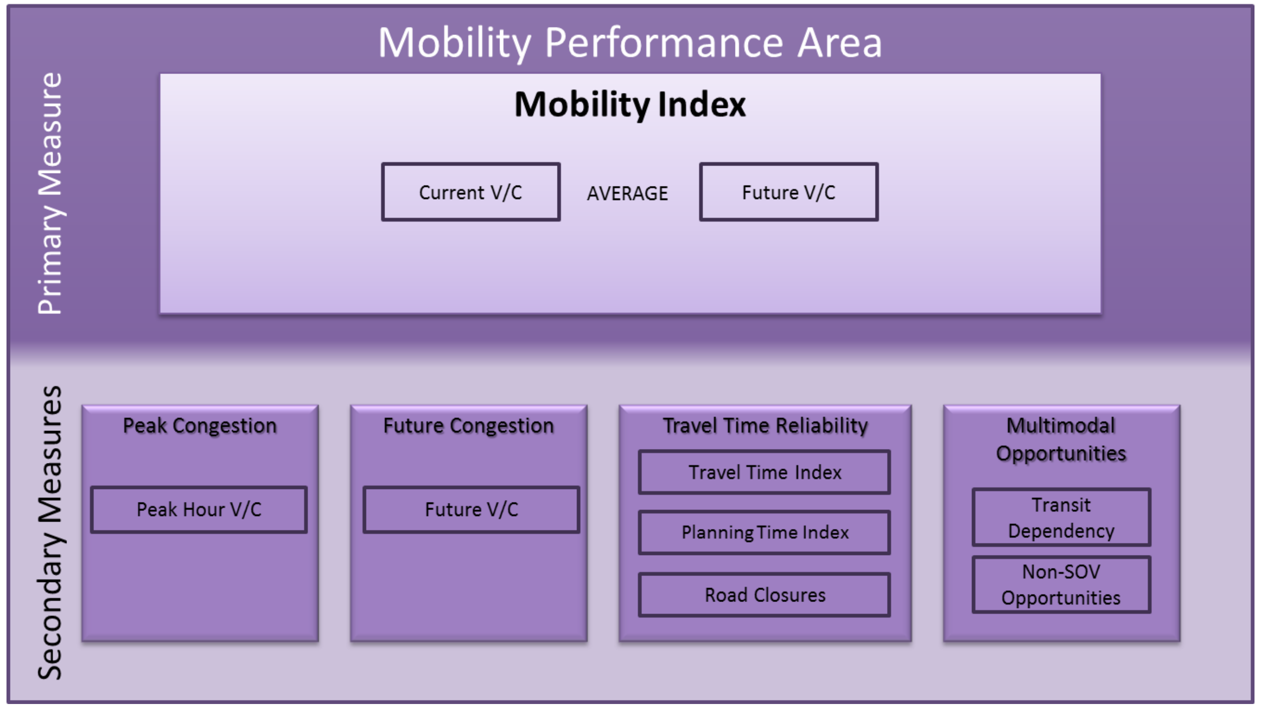
Sufficiency Rating	
Good	>80
Fair	50-80
Poor	<50

Bridge Rating	
Good	>6
Fair	5-6
Poor	<5

% Functionally Obsolete	
Better	< 12%
Average	12%-40%
Worse	>40%

Mobility Performance Area Calculation Methodologies

This Appendix summarizes the approach and methodology to develop the primary and secondary performance measures in the Mobility Performance Area as shown in the following graphic.



<u>Primary Measure</u>

The primary Mobility Index is an average of the current volume to capacity (V/C) ratios and the projected future V/C ratios for each segment throughout the corridor.

<u>*Current V/C*</u>

The current V/C ratio for each segment is calculated by dividing the 2014 Annual Average Daily Traffic (AADT) volume for each segment by the total Level of Service (LOS) E capacity volume for that segment

The capacity (C) is calculated using the HERS Procedures for Estimating Highway Capacity[1]. The HERS procedure incorporates HCM 2010 methodologies. The methodology includes capacity estimation procedures for multiple facility types including freeways, rural two-lane highways, multilane highways, and signalized and non-signalized urban sections.

The segment capacity is defined as a function of the number of mainline lanes, shoulder width, interrupted or uninterrupted flow facilities, terrain type, percent of truck traffic, and the designated urban or rural environment.

[1] HERS Support – 2011, Task 6: Procedures for Estimating Highway Capacity, draft Technical Memorandum. Cambridge Systematics. Prepared for the Federal Highway Administration. March 2013.

The AADT (V) for each segment is calculated by applying a weighted average across the length of the segment based on the individual 24 hour volumes and distances associated with each HPMS count station within each segment.

The following example equation was used to determine the weighted average of a segment with two HPMS count locations within the corridor

((HPMS 1 Distance x HPMS 1 Volume) + (HPMS 2 Distance x HPMS 2 Volume))/Total Segment Length

For specific details regarding the HERS methodology used, refer to the *Procedures for Estimating Highway Capacity, draft Technical Memorandum.*

<u>*Future V/C*</u>

The future V/C ratio for each segment is calculated by dividing the 2035 AADT volume for each segment by the 2013 LOS E capacity. The capacity volume used in this calculation is the same as was utilized in the current V/C equation.

The future AADT volumes are generated by applying an annual compound growth rate (ACGR) to each 2013 AADT segment volume. The following equation was used to apply an annual compound growth rate:

2035 AADT = 2013 AADT x ((1+ACGR)^22)

The ACGR for each segment was defined by comparing the total volumes in the 2010 Arizona Travel Demand Model (AZTDM2) to the 2035 AZTDM2 traffic volumes at each existing HPMS count station location throughout the corridor. Each 2010 and 2035 segment volume was defined using the same weighted average equation described in the *Current V/C* section above then summing the directional volumes for each location. The following equation was used to determine the ACGR for each segment:

ACGR = ((2035 Volume/2010 Volume)^(1/25))-1

<u>Primary Index Rating Thresholds</u>

The following V/C thresholds were assigned for each environment type as indicated based on current ADOT roadway design standards.

<u>Urban and Fringe Urban</u>

Good - LOS A-C	V/C ≤ 0.71	*Note - ADOT Roadway Design Standards indicate Urban and Fringe Urban roadways should be designed to level of service C or better
Fair - LOS D	V/C > 0.71 & ≤ 0.89	
Poor - LOS E or less	V/C > 0.89	

<u>Rural</u>

Good - LOS A-B	V/C ≤ 0.56	*Note - ADOT Roadway Design Standards indicate Rural roadways should be designed to level of service B or better
Fair - LOS C	V/C > 0.56 & ≤ 0.76	
Poor - LOS D or less	V/C > 0.76	

<u>Secondary Measures</u>

Peak Congestion

Peak Congestion has been defined as the peak hour V/C ratio in both directions of the corridor. The peak hour V/C ratio is calculated using the HERS method as described above. The Peak Hour volume utilizes the directional AADT for each segment which is calculated by applying a weighted average across the length of the segment based on the individual directional 24 hour volumes and distances associated with each HPMS count station within each segment. The segment capacity is defined based on the characteristics of each segment including Number of Lanes, Terrain Type, and Environment, similar to the 24 hour volumes using the HERS method.

Peak Congestion Rating Thresholds
The same thresholds identified for the 24hr V/C ratios were applied to the Peak Congestion V/C values.

Future Congestion

The future V/C ratios for each segment in the corridor that were calculated and used in the Primary Mobility Index as part of the overall average between Current V/C and Future V/C were applied independently as a secondary measure. The methods to calculate the Future V/C can be referenced in the Primary Mobility Index section.

Travel Time Reliability

Travel time reliability is a measure that includes the number of times a piece of a corridor is closed for any specific reason, the directional Travel Time Index (TTI), and the Planning Time Index (PTI).

Directional Closures

The number of times a roadway is closed is documented through the HCRS dataset. Directional Closures was defined as the average number of times a segment of the corridor was closed per year mile in a specific direction of travel per year. The weighted average of each occurrence takes into account the distance over which a specific occurrence spans.

Directional Closures Thresholds
Thresholds that determine levels of good, fair, and poor are based on the average number of closures per mile per year within each of the nine identified statewide significant corridors by ADOT. The following thresholds represent statewide averages cross those corridors:

Good	≤ 0.22
Fair	> 0.22 & ≤ 0.62
Poor	V/C > 0.62

Directional Travel Time and Planning Time Index

In terms of overall mobility, the travel time index (TTI) is the relationship of the posted speed limit in a specific section of the corridor to the mean peak hour speed in the same location. The planning time index (PTI) is the relationship of the 5th percentile of the lowest mean speed to the posted speed limit in a specific section of the corridor. Using HERE data provided by ADOT, four time periods for each data point were collected throughout the day (AM Peak, Mid-Day, PM Peak, and Off-peak). Using the mean speeds and 5th percentile lowest mean speeds collected over 2013 for these time periods for each data location, four TTI and PTI calculations were made using the following formulas:

TTI = Posted Speed Limit/Mean Peak Hour Speed

PTI = Posted Speed Limit/5th Percentile Lowest Speed

The highest value of the four time periods calculation was defined as the TTI for that data point. The average TTI was calculated within each segment based on the number of data points collected. The value of the average TTI across each entry was used as the TTI for each respective segment within the corridor.

Multimodal Opportunities

Transit Dependency

2008-2012 U.S. Census American Community Survey tract and state level geographic data and attributes from the tables B08201 (Number of Vehicles Available by Household Size) and B17001 (Population in Poverty within the Last 12 Months) were downloaded with margins of error included from the Census data retrieval application Data Ferret. Population ranges for each tract were determined by adding and subtracting the margin of error to each estimate in excel. The tract level attribute data was then joined to geographic tract data in GIS. Only tracts within a one mile buffer of each corridor are considered for this evaluation.

Tracts that had a statistically significantly larger number of either people in poverty or households with only one or no vehicles available than the state average was considered potentially transit dependent.

Example: The state average for Zero or One Vehicles HHs is between 44.1% and 45.0%. Tracts which have the LOWER bound of their range above the UPPER bound of the state range definitely have a greater percentage of zero/one vehicle HHs than the state average. Tracts that have their UPPER bound beneath the LOWER bound of the state range definitely have a lesser percentage of zero/one vehicles HHs than the state average. All other tracts that have one of their bounds overlapping with the state average cannot be considered statistically significantly different because there is a chance the value is actually the same.

Transit Dependency Rating Methodology

Green	Tracts with both zero and one vehicle household and population in poverty percentages below the statewide average
Yellow	Tracts with either zero and one vehicle household OR population in poverty percentages within the statewide average
Red	Tracts with both zero and one vehicle household and population in poverty percentages above the statewide average

In addition to transit dependency, the following attributes were added to the Multimodal Opportunities map based on available data.

1. Shoulder width throughout the corridor based on 'Shoulder Width' GIS dataset provided by ADOT.
2. Intercity bus routes
3. Multiuse paths within the corridor ROW if applicable

% Non SOV Trips

The percentage of non-single occupancy vehicle trips over distances less than 50 miles gives an indication of travel patterns along a section of the corridor that could benefit from additional multimodal options in the future.

% Non-SOV Thresholds
Thresholds that determine levels of good, fair, and poor are based on the % Non SOV trips within each of the nine identified statewide significant corridors by ADOT. The following thresholds represent statewide averages cross those corridors:

Good	≥ 17%
Fair	> 11% & ≤ 17%
Poor	< 11%

Bicycle Accommodation

For this secondary performance evaluation, shoulder widths are evaluated considering the roadway's context and conditions. This requires use of the roadway data that includes right shoulder widths, shoulder surface types, and speed limits. All of which are available in the following ADOT GIS data sets:

- Right Shoulder Widths
- Left Shoulder Widths (for undivided roadways)
- Shoulder Surface Type (Both Left/Right)
- Speed Limit

Additionally, each segment's average AADT, estimated earlier in the Mobility methodology, will be used for the criteria to determine if the existing shoulder width meets the effective width.

The criteria for screening if a shoulder segment meets the recommended width criteria are as followed:

(1) If AADT <= 1500 OR Speed Limit <= 25 MPH:
The segment's general purpose lane can be shared with bicyclists (no effective shoulder width required)

(2) If AADT > 1500 AND Speed Limit between (25 - 50 MPH) AND Pavement Surface is Paved:
Effective shoulder width required is 4 feet or greater

(3) If AADT > 1500 AND Speed Limit >= 50 MPH And Pavement Surface is Paved:
Effective shoulder width required is 6 feet or greater

The summation of the length of the shoulder sections that meet the defined effective width criteria, based on criteria above, will be divided by the segments total length to estimate the percent of the segment that accommodates bicycles as illustrated below with the following thresholds.

Good	≥ 90%
Fair	> 60% & ≤ 90%
Poor	< 60%

Mobility Data Input Instructions

Note: Only input values into Beige colored cells, all other cells will auto populate

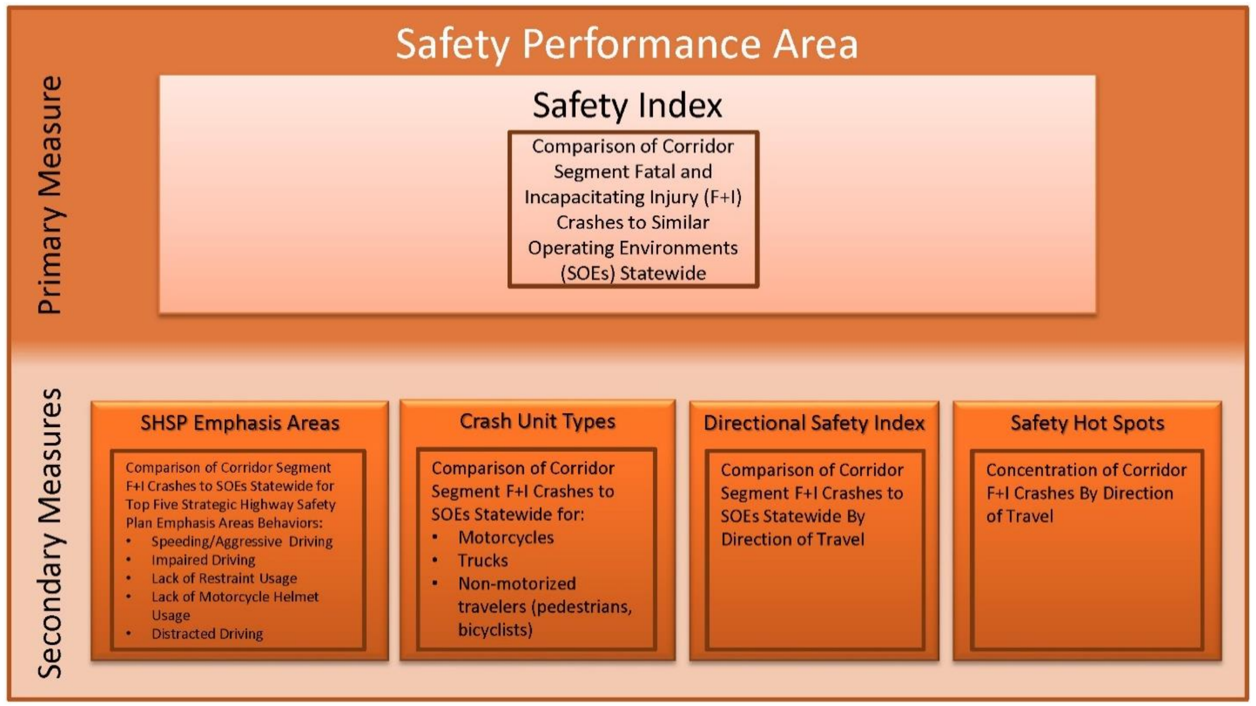
1. On the 'Supporting Data' tab input Corridor Name in cell D4
   a. *This needs to be filled in with I-10, I-40, SR 87 etc. to pull correct formula*
2. On same tab, input corridor specific information in appropriate cells
   a. Begin MP
   b. End MP
   c. Facility Type – drop down selection on of the following:
      i. Urban – Generally fully developed area, mile spaced TIs, and a 65 mph speed limit
      ii. Fringe Urban – more than 5,000 population not in an urban area, moderate levels of development and a speed limit that is transitioning from 65 mph to faster speeds
      iii. Rural – Less than 5,000 population, low levels of development, and a 75 mph speed limit
   d. Flow Type – drop down selection one of the following:
      i. Uninterrupted – Segment does not have any characteristics that would require motorists to stop. (i.e. signal, stop sign, border check point, etc.)
      ii. Interrupted – Segment does have characteristics that would require motorists to stop. (i.e. signal, stop sign, border check point, etc.)
   e. Terrain – drop down selection one of the following:
      i. Level – Using the GIS 'Grade' dataset provided by ADOT if the majority of your segment is A or B.

   ii. Rolling – Using the GIS 'Grade' dataset provided by ADOT if the majority of your segment is C.
   iii. Mountainous – Using the GIS 'Grade' dataset provided by ADOT if the majority of your segment is D or higher
 f. Number of lanes (both directions)
 g. Capacity Environment Type – drop down selection one of the following using the criteria identified on the 'drop down menus' tab
   i. Freeway Segments
   ii. Multilane Highway
   iii. Urban/Rural Single or Multilane Signalized
   iv. Rural Two-Lane, Non-Signalized
   v. Urban 1/2/3 Lane Highway
 h. Lane Width in feet
   i. If a segment has more than one lane width, calculate the weighted average and use that number here.

3. Using HPMS supplemental spreadsheet, copy and paste values for directional AADT, 2014 AADT, K, D, and T Factor.
4. Using the 'Speed Limit' GIS dataset provided by ADOT, calculate the weighted average by segment and use that number.
5. Select 'divided' or 'undivided' from drop down menu
6. Depending on Capacity Environment Type selected, 'Access Points' or 'Street Parking' will highlight and ask for a value to be entered.
   a. Access Points – Calculate the access points per mile for each segment using the total number of intersections or driveways present.
   b. Street Parking – select from drop down menu.
7. Using the 'No-Passing Zones' dataset provided by ADOT, input the percentage of each segment that is designated as a 'No Passing Zone'
   a. If 'No-Passing Zones' column auto populates, do not enter any value. If 'No-Passing Zone' column indicates 'Enter Value', enter value from statewide dataset.
8. On 'Statewide Shoulder Info' tab, filter 'RouteId' column to show your corridor. For corridors with multiple routes, select each individual route.
9. Using 'FromMeasure' and 'ToMeasure' columns, identify the MP limits for each segment of your corridor and copy corresponding 'IDNUM' numbers to the appropriate column on the 'Bicycle Accommodation' tab.
   a. Using the 'Shoulder Width' GIS shapefile provided by ADOT, confirm the MP limits associated with your corridor for the shoulder data in 'FromMeasure' and ToMeasure' columns match the actual MP on your corridor.
   b. If they do not, calculate the offset (it should be consistent) between the datafile and the actual MP on your corridor.
   c. If the MP limits in the statewide dataset are offset from the actual MP limits of your corridor, input an offset value above the 'FromMeasure' and 'ToMeasure' columns on the 'Bicycle Accommodation' tab.
10. Input appropriate segment number for each 'IDNUM' number on 'Bicycle Accommodation' tab.
   a. If an entry spans segment lengths input the first segment it falls within in the segment column.
   b. Copy that same IDNUM number into a blank row in the IDNUM column and input the second segment it is associated with.
11. On 'Reliability Inputs' tab, copy segment values from 'Summary' tab from both the Closures and PTI/TTI supplemental spreadsheets.
12. On 'AZTDM Inputs' tab, copy segment values from 'Summary' tab from AZTDM supplemental spreadsheet.

Safety Performance Area Calculation Methodologies

This document summarizes the approach for developing the primary and secondary performance measures in the Safety Performance Area as shown in the following graphic.



<u>"Safety Performance Summary" Tab</u>

1. This tab references and summarizes information from the other tabs in the spreadsheet and includes the performance analysis results for the overall Safety Index (the primary safety performance measure) as well as the secondary Safety performance measures.
2. All data should be entered in the "Safety Performance Summary" tab except for a manual assessment of the sample size in the "Secondary Measures" tab.
3. Use the pull-down menu to select the Similar Operating Environment (SOE) that best describes each segment. If this information is not known, it is already included in the crash data and in a separate GIS highway segment file available from ADOT.
4. If a corridor segment contains portions of multiple SOE categories, designate the corridor segment as the SOE category that covers the majority of the segment length. If there is no majority SOE category in a segment, designate the segment as the SOE category with the lowest statewide average crash frequency and rate values.
5. Fill in the segment length. This information is used in calculating the Safety Index.
6. Determine how many fatal and incapacitating injury crashes occurred in each direction (based on the UnitTravelDirectionDesc field in the crash data contained in Statewide_F+I_Crashes_w_SOE (2010-2014).xlsx) within each corridor segment during the five-year analysis period and enter this information into the corresponding beige cells.
7. To fill in the number of crashes involving a Strategic Highway Safety Plan (SHSP) Top 5 Emphasis Areas behavior, use the Emphasis column in the crash data and count how many crashes in the segment have a "Y" in that column.
8. To fill in the number of crashes involving trucks, motorcycles, and non-motorized travelers (pedestrians and bicyclists), use the UnitBodyStyleDesc column in the crash data to identify how many fatal and incapacitating injury crashes contain each of the field attributes listed below:
   - -Truck-involved crashes – all UnitBodyStyleDesc codes that start with Truck;
   - -Motorcycle-involved crashes – all UnitBodyStyleDesc codes that start with Motorcycle;
   - -Non-motorized traveler-involved crashes – PersonTypeDesc codes of Pedestrian or Pedalcyclist.
9. Copy the 2010-2014 weighted five-year average bi-directional and directional average annual daily traffic (AADT) volumes from the HPMS_Summary.xlsx. The HPMS spreadsheet includes directions for how to identify relevant AADT values in the corridor and then automatically summarizes them as weighted AADT values.

<u>"Safety Index" Tab</u>

1. This tab calculates the safety index and directional safety index based on the data input in the "Safety Performance Summary" tab and provides the safety index performance results to the "Safety Performance Summary" tab. No input is needed on this tab.

<u>"Secondary Measures" Tab</u>

1. This tab calculates the remaining secondary safety measures based on the data input in the "Safety Performance Summary" tab and provides the secondary safety measure performance results to the "Safety Performance Summary" tab.
2. The only input needed on this tab is in Column N related to sample size assessment. Due to the instability of small sample sizes, segment secondary performance measure levels that discuss crash types should be removed and replaced with "Insufficient Data" if any of the following criteria are met (this does not apply to the directional Safety Index):
   a. adding or removing one fatal or incapacitating injury crash of the secondary performance measure type (e.g., SHSP Top 5, Truck) changes the segment performance measure value two levels (e.g., from Above Average (red color) to Below Average (green color) , regardless of the number of fatal + incapacitating injury crashes in the segment over the five-year analysis period);
   b. there are fewer than five total fatal + incapacitating injury crashes (of any type) in a segment;
   c. if the average segment crash frequency of the overall corridor is fewer than two fatal + incapacitating injury crashes of that secondary performance measure type over the five-year analysis period, the entire secondary performance measure should be eliminated from further analysis due to insufficient sample size.
3. Of the three aforementioned sample size criteria, two of the three automatically determine if the sample size is insufficient. For the other criteria that deals with the segment performance measure value changing two levels, the user needs to use the pulldown menu to indicate if the performance changed two levels or not by adding or subtracting one crash.

<u>"Statewide F+I Summary_WghtdAADT" Tab</u>

1. This tab provides the back-up for how the low and high thresholds of average safety performance were calculated at the statewide level for each of the SOEs. No input is needed on this tab.

Safety Index

To calculate the Safety Index, you will need to identify the fatal and incapacitating injury crashes that occur on each study corridor segment as well as on other roadway segments statewide that have similar operating environments. You will also need to determine segment lengths and average annual daily traffic (AADT) volumes for use in developing crash rates.

Directional Safety Index

See the directions for the Safety Index, with the only difference being that crashes are separated out by direction using the UnitTravelDirectionDesc field in the crash data.

SHSP Emphasis Areas

ADOT's Strategic Highway Safety Plan (SHSP) identifies several emphasis areas. The top five SHSP emphasis areas relate to the following driver behaviors:

- Speeding/Aggressive Driving
- Impaired Driving
- Lack of Restraint Usage
- Lack of Motorcycle Helmet Usage
- Distracted Driving

To determine how well a particular corridor segment performs in these five emphasis areas, the relative frequencies of the aforementioned driver behaviors at the corridor segment level can be compared to SOE segments statewide. To avoid large swings in performance due to one or two crashes where the sample size is small, the five emphasis areas behaviors are combined to identify crashes that exhibit one or more of the emphasis areas behaviors:

a. Speeding/Aggressive Driving – PersonViol codes of Exceeded Lawful Speed, Followed Too Closely, Unsafe Lane Change, Passed in No-Passing Zone, Other Unsafe Passing;
b. Impaired driving – PersonPh_2 code of Physical Impairment, PersonPh_3 code of Fell Asleep/Fatigued, PersonPh_4 code of Alcohol, PersonPh_5 code of Drugs, PersonPh_6 code of Medication;
c. Lack of Restraint Usage – PersonSafe code of None Used;
d. Lack of Motorcycle Helmet Usage – PersonSafe code of None Used (already included in Lack of Restraint Usage);
e. Distracted driving – PersonViol codes of Inattention/Distraction and Electronic Communication Device.

Crash Unit Types

ADOT's SHSP also identifies emphasis areas that relate to the following unit or entity type involved in crashes:

- Heavy Vehicles (Trucks)
- Motorcycles
- Non-Motorized Travelers (pedestrians and bicyclists)

To determine how well a particular corridor segment performs in these emphasis areas, the relative frequencies of the aforementioned crash unit types at the corridor segment level can be compared to SOE segments statewide. To avoid large swings in performance due to one or two crashes where the sample size is small, these emphasis areas should only be mapped if the sample size is sufficiently large.

Safety Hot Spots

A "hot spot" analysis identifies abnormally high concentrations of crashes. This analysis of fatal and incapacitating injury crashes along the study corridor by direction of travel involves the following steps:

1. Using the fatal and incapacitating injury crashes selection set developed previously for the Safety Index for corridor segments, separate the crashes by direction of travel using the field named UnitTravelDirectionDesc.
2. In ArcGIS Toolbox, open the 'Kernel Density' tool. The input file is the fatal and incapacitating injury crashes selection set by direction file. The population field should be set to 'NONE'. For the output cell size, use a value of 50 feet. For the search radius, use a value of 10,560 feet (2 miles).
3. Create a map showing the results as a raster dataset.
4. Change the Equal Interval map symbology display to have 2 classes, and then manually change the upper limit of the first class to 0.000000035. Then change the first class color to null and the second class color to red (RGB 245 0 0).
5. Identify the approximate milepost limits of the hot spot and note the hot spot with milepost limits on the Directional Safety Index figure.

Freight Performance Area Calculation Methodologies

The Appendix summarizes the approach for developing the primary and secondary performance measures in the Freight Performance Area as shown in the following graphic.

Freight Index, TTTI, and TPTI

1. Open the file called Freight Performance Index - Template_02-05-16.xlsx. This file contains several tabs. The "Freight Performance Area" tab is a summary of the various performance measure results for the Freight Performance Area.
2. In the "Freight Performance Area" tab, fill in the segment numbers and mileposts and, using the dropdown list in the Facility type column, identify whether the facility is considered interrupted or uninterrupted flow. For more information on interrupted/uninterrupted flow designations for each segment of the corridor, see the Mobility Performance Area as these same designations are applied there.
3. The Freight Index, Truck Travel Time Index (TTTI), and Truck Planning Time Index (TPTI) values in the "Freight Performance Area" tab are pasted in from a separate spreadsheet called Travel-Time_Reliability_Template_02-05-16.xlsx.
4. The Travel-Time Reliability spreadsheet includes a "TMC Locations" tab that identifies the locations of the TMCs (count locations) that are part of the HERE travel data collection network. Import the "TMC Locations" tab data into GIS and use the lat/lon coordinates to identify which TMCs pertain to each segment of the corridor. If a TMC is at a segment boundary, assign it to the segment containing fewer TMCs. The fourth digit in the TMC identifier is a 'P' or 'N'. 'P' stands for 'positive' cardinal direction (NB or EB) while 'N' stands for 'negative' cardinal direction. There are typically a 'P' TMC and 'N' TMC at each location.
5. In the "Statewide Data" tab of the Travel-Time Reliability spreadsheet, filter the data to only show the TMCs that pertain to the corridor. Organize the data by segment and direction. There are typically four time periods that pertain to each TMC. Note: Some TMCs will not have a corresponding TMC in the opposite direction of travel. It is important not to treat a missing value as a zero in the following calculations.
6. In the Travel-Time Reliability spreadsheet, copy the rows for the relevant TMCs from the "Statewide Data" tab to the "NB-EB" tab for positive cardinal TMCs and to the "SB-WB" tab for negative or non-cardinal TMCs. Keep the TMC locations consistent with the corridor segment in which they are located and in the appropriate direction.
7. The "SpeedLimit" tab of the Travel-Time Reliability spreadsheet contains posted speed limit data. Locate the corridor's speed limit data and copy it into both the "NB-EB" and "SB-WB" tabs. This information is for use in determining the assumed free-flow speed.
8. The information generated from the four prior steps is summarized in the "Summary" tab of the Travel-Time Reliability spreadsheet. This tab includes TTI and PTI information that should be pasted into the Mobility Performance spreadsheet and Freight Index, TTTI, and TPTI information that should be pasted into the "Freight Performance Area" tab of the Freight Performance spreadsheet.
9. The "Freight Performance Area" tab categorizes the performance of the Freight Index of each uninterrupted flow segment into one of three levels: Poor < 0.67, Fair 0.67-0.77, and Good > 0.77. Similarly, the TTTI performance thresholds are: Poor > 1.33, Fair 1.15-1.33, and Good < 1.15 and the TPTI performance thresholds are: Poor > 1.5, Fair 1.3-1.5, and Good < 1.3. The segment performance values are then colored depending on their performance level, with the color red for Poor, yellow for Fair, and green for Good performance levels.
10. Similarly, the "Freight Performance Area" tab categorizes the performance of the Freight Index of each interrupted flow segment into one of three levels: Poor < 0.17, Fair 0.17-0.33, and Good > 0.33. Similarly, the TTTI performance thresholds are: Poor > 2.0, Fair 1.3-2.0, and Good < 1.3 and the TPTI performance thresholds are: Poor > 6.0, Fair 3.0-6.0, and Good < 3.0. The segment performance values are then colored depending on their performance level, with the color red for Poor, yellow for Fair, and green for Good performance levels.
11. Create a map showing the Freight Index performance level by color for each segment. Directional maps should also be created that show the TTTI and TPTI performance level color for each segment.

Road Closure Duration

1. The directional road closure duration values in the "Freight Performance Area" tab are pasted in from a separate spreadsheet called New Closure Calcs.xlsx. The New Closure Calcs spreadsheet contains data generated by ADOT's Highway Condition Reporting System (HCRS) on when full directional closures of mainline traffic occur, how long they last, and what mileposts they impact. Corridor-specific

information has already been identified for each corridor being studied, as have statewide “typical” values for closure duration.

2. Paste the directional road closure duration information on the number of minutes per year a given milepost averaged over the last five years into the “Freight Performance Area” tab of the Freight Performance spreadsheet.

3. Create a map showing the average minutes per year a given milepost is closed per segment mile by performance level color for each segment.

<u>Bridge Vertical Clearance Restrictions and Hot Spots</u>

1. Input characteristics of each bridge into the "Bridge Vertical Clearance" tab of the Freight Performance Index file by segment number. These bridges are the same structures identified in the Bridge Performance Area (i.e., culverts are excluded). The value in parentheses indicates where this information can be found in the "Round 1 Bridge Info" tab (for Round 1 corridors) or the “Bridge Info_BrM_Grid_Export” (for Round 2 and Round 3 corridors).

2. Using the dropdown list in the Ramps Allow Oversize Mainline Traffic to Avoid Bridge column in the "Bridge Vertical Clearance" tab, visually identify via aerials which bridges identified as "UP", (meaning the mainline passes under the bridge) can be ramped around (i.e., avoided) and which have no ramp within a mile of the bridge.

3. List the bridge structure names, number, and milepost in each segment in the Vertical Clearance Hot Spot column in the "Freight Performance Area" tab that are identified in the Hot Spot Vertical Clearance column in the "Bridge Vertical Clearance" tab as being Hot Spot bridges.

4. Create a map showing the vertical clearance restrictions, with symbols for locations that are hot spots where ramps do not exist and the vertical clearance restriction of < 16’3” cannot be avoided.